# report on
# mosquito control
# programs
# in manitoba

MANITOBA
CLEAN ENVIRONMENT COMMISSION
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# MOSQUITO CONTROL PROGRAMS

# IN

# THE PROVINCE OF MANITOBA

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# PREFACE

As in many other areas of the world, mosquitoes in Manitoba are a problem to man and, indeed, to many other mammals and birds.

The earliest recorded history of settlement in Manitoba and the Red River colony contains accounts of the discomfort and otherwise disruptive effect of the hordes of mosquitoes which at times prevailed. Their effect on both wild and domestic animals and on man was great and was undoubtedly considered by the early settlers to be, at the least, a very great nuisance, if not much more than a nuisance.

Northern Manitoba, with its vast areas of water and woods, is extremely amenable to the development of the mosquito population, as is the eastern and southeastern portion of the Province which lies within the Precambrian Shield. It appears likely that, within the prairie region, the Red River area including Winnipeg City, also has a particularly bad mosquito problem.

Because the presence of mosquitoes in large numbers greatly affected the outdoor enjoyment of Manitoba's relatively short summer season, organized efforts were made, commencing in the 1920's, to reduce the magnitude of the mosquito outbreaks by means of rudimentary larviciding programs in the Winnipeg area. This was done by the spraying of oil on ponds of water, largely by teams of men on foot, with backpack spray equipment.

Many early formulations designed for application to the skin as a repellent, were also developed and marketed.

The identification of the presence in Manitoba of the disease western equine encephalitis in the 1930's, followed by serious outbreaks of the disease in the 1940's, was a further cause for concern about the control of mosquitoes, a species of which was identified as the major carrier of the disease virus.

The second world war led to the development of new chemical insecticides, primarily DDT, which was initially hailed as a boon to mankind as a means of controlling insect pests and associated diseases. It was effective, but undesirable side effects became apparent over time and, as a result, the use of this chemical was restricted in 1969.

The aftermath of the war also saw the introduction of the chemical fogging machine, originally developed to provide smoke screens for naval operations. This was adapted for use in dispensing the modern chemical insecticides in recreational areas, and sometimes in residential areas. This added a new dimension to the possibility for mosquito control; that of killing large numbers of adult mosquitoes or adulticiding. This supplemented, rather than replaced, previously developed larviciding programs. Adulticiding programs have been used extensively in outdoor recreational areas, as well as in some residential areas. There are also doubts, in the minds of many, about the efficacy of spraying programs and about possible long-term environmental and health effects.

Any statement of The Clean Environment Comission expressing degrees of safety pertaining to chemical insecticides is not a black and white position. These chemical insecticides are considered poisonous in that they were developed to kill insects. Therefore, compliance with label instructions and application rates is exceptionally important.

The Commission has addressed many aspects of mosquito control in the following report, based upon the submissions it received during and after the hearings conducted earlier this year. Conclusions have been reached and are stated throughout the report in the various chapters and sections. In order to fully understand the arguments and conclusions reached, it is necessary to read fully the text and the development of these conclusions.

# SECTION 1

## GENERAL

### 1-1. Authorization of the Investigation

By letter of March 25, 1982, The Honourable Jay Cowan, Minister Responsible for Environmental Management, requested The Clean Environment Commission to investigate present mosquito control programs. The letter from the Minister, which was addressed to the Chairman of The Clean Environment Commission, is attached to this report as Appendix 1.

The Minister referred to ongoing public concerns about mosquito control programs. He requested that the Commission, by this investigation, determine the extent of the problems that are perceived and develop guidelines and regulations, as may be required. Specifically, the Minister asked The Clean Environment Commission to hold public hearings pursuant to Section 13(1) of The Clean Environment Act and to provide him with a report and recommendations prior to the next control season.

The Minister did not place any restrictions on the investigation but asked that the Commission place emphasis on:

1) an assessment of existing and potential environmental problems associated with existing control procedures, and of alternative methods;

2) a review of the efficacy of existing control methods and of alternative methods;

3) a review of existing legislation and procedures, with recommendations as to what changes in provincial legislation may be required.

It is clear from this letter that the Minister expected the Commission to investigate the entire problem of mosquito control and to recommend, in a practical operational sense, what action should be taken by the Government.

## 1-2. Scope of the Investigation

This is not the first time that The Clean Environment Commission has dealt with mosquito control programs. On previous occasions, however, the public hearings held were in response to requests by municipalities for a Commission order concerning a particular control program. The object of those hearings was, therefore, the determination of appropriate limits for specific applications of insecticide in the environment.

The present investigation goes well beyond this objective. Firstly, it includes the matter of aerial spraying as a means of controlling an outbreak of western equine encephalitis. Aerial sprayings were authorized by the Manitoba Cabinet in the years 1975, 1977, and 1981 in response to health emergencies.

Secondly, the present investigation must address alternative methods of control of both nuisance mosquitoes and of western equine encephalitis carriers.

Thirdly, the question of the efficacy of mosquito control programs must also be considered.

Finally, the investigation must deal with the adequacy of legislative control. This requires recommendations regarding adequate public policy in mosquito control and the appropriate legislative means of implementing that policy.

This report is limited to mosquito control programs and does not examine the question of the control of other biting insects.

It soon became clear that the scope of the investigation made it impossible to complete a full report prior to the 1982 mosquito control season. For this reason, the Commission prepared an interim report related to the control of western equine encephalitis, which was submitted to the Minister on July 16, 1982, and is attached as Appendix 2 to this report. In this interim report, the Commission presented the Minister with its advice and recommendations regarding this matter, so that he would be apprised of its views in the event that the province experienced another outbreak of western equine encephalitis in 1982. The interim report did not deal with nuisance mosquito control programs.

## 1-3. Organization of the Report

The Clean Environment Commission held public hearings in Winnipeg on May 12, 13, 14, and 17, 1982; in Brandon on May 18, 1982; in Dauphin on May 19, 1982; and in Thompson on May 25, 1982. Copies of the advertisements for these hearings are attached as Appendix 3 to this report.

At these hearings, the Commission received numerous formal and informal submissions of fact and opinion from involved agencies and from the general public. A list of the formal submissions is attached to the Report as Appendix 4. All presentations and discussions were recorded verbatim. Additional material was received after the hearings were terminated. As a result, a large amount of information was submitted and was used as the basis for this report. The quality of the presentations was excellent and showed evidence of commendable care and effort in preparing these contributions to the consideration of an important public issue.

The material under discussion can be divided into five distinct parts. These are:

Section 2 - Chemical Insecticides Used For Mosquito Control

Section 3 - Control of Nuisance Mosquitoes

Section 4 - Western Equine Encephalitis

Section 5 - Legislative Changes

Section 6 - Recommendations

The first area of concern in Section 2 is the degree of risk in the use of insecticides in general and the environmental and health problems that could conceivably arise with insecticides that are used for mosquito control. This section addresses the regulatory responsibility assumed by the Federal Government. It then focusses on specific concerns that have been expressed about the degree of safety of particular pesticides.

Section 3 deals with the control of nuisance mosquitoes and Section 4 with western equine encephalitis. These are separate and distinct issues as will be made clear in the discussion. In each case, the relative safety as well as the efficacy of the present methods of control are examined. Alternative methods of control are discussed.

Section 5 deals with provincial legislation and regulatory procedures, not only in Manitoba but also in Ontario, Saskatchewan, and Alberta. Legislative weaknesses in Manitoba are identified and possible improvements are examined.

Section 6 lists the conclusions and recommendations arrived at by the Commission.

Throughout the report, conclusions are drawn and solutions considered.

# SECTION 2

# CHEMICAL INSECTICIDES USED FOR MOSQUITO CONTROL

## 2-1. Introduction

Responsible use of chemicals for the control of mosquitoes must steer a careful course between two extreme positions. On the one hand, many people in our society would use chemicals as a remedy for any bothersome condition. On the other hand, there are people who oppose the use of any chemical insesticides on the grounds that there may be harmful side effects.

The contention that the use of chemical insecticides entails some element of risk cannot be denied. By their very nature, insecticides are poisons, aimed at destroying life although they are designed to be selective in their action. Extensive testing is performed to ensure that their effect on nontarget species is environmentally acceptable and that human health is not endangered when the products are used in accordance with the label instructions. But that does not eliminate all risk. With frequent and large-scale application in the extremely variable conditions of real life, one may produce effects that could not be predicted from the laboratory and field tests that were conducted under controlled conditions. At the same time, the complexity of the real life situation may mask cause and effect relationships, especially for long-term effects. Harmful effects of insecticides, should these occur, may, therefore, not be diagnosed for what they are. One must also recognize that the operational use of insecticides is bound to entail, at times, operational error. Common sense, therefore, dictates that insecticides be treated as potentially dangerous chemicals. They should not be used unless it can be adequately demonstrated that the benefits clearly outweigh their risk in each instance. The safety and efficacy of the chemicals are important considerations.

The discussion will begin with a review of the role the Federal Government plays in regulating the use of pesticides. Since access to actual test results on the chemicals is restricted, it is essential that the methodology of the Federal Government in this respect is understood and that its findings and actions are correctly interpreted.

Next, the various chemical insecticides commonly used in mosquito control programs in Manitoba will be discussed. The purpose of this discussion is not to present a complete picture, but to clarify which chemicals are used, how they are used and what their possible effect could be on nontarget species and on human health. Particular emphasis will be placed on those aspects that have become objects of public controversy, for example, the relative safety of the insecticide Baygon.

## 2-2. The Regulatory Role of the Federal Government

The Federal Department of Agriculture administers the Pest Control Products Act through its Pesticide Division. Central in this federal legislation is the provision that all pesticides must be registered by Agriculture Canada before they may be offered for sale.

Prior to registration, the Pesticide Division conducts a preregistration review of the product. This deals not only with the active ingredients, but also with the carriers and with any additives or contaminants that may be present. Attention is also given to possible synergistic effects or potentiation of a substance due to the presence of other chemicals.

To conduct this review, the department requires the manfacturer, first of all, to provide a large amount of research based data. These may have been produced by the manufacturer himself or by consultant laboratories on his behalf. Additional information is usually obtained from researchers at universities or in federal departments that have an interest in the product. In the interpretation of the data and the specification of additional studies, the Department of Agriculture relies heavily on consultation with others, in particular with other federal agencies such as the Department of Health and Welfare, the Department of Fisheries and Oceans, and the Department of the Environment.

Safety and efficacy depend on the use that is made of the pesticide. For this reason, the Pesticide Division carefully examines the so-called label instructions which specify in detail the conditions of use, such as concentration, rate, time and frequency of application, safety conditions, disposal of empty containers, etc. It is an offense to use a registered pesticide contrary to the label instructions but enforcement is difficult.

Registration is not the end of the Department's involvement with the product. The Pesticide Division also monitors the use of the product and may reevaluate it if there are doubts about its safety or efficacy.

Without going into detail about the evaluation, it may be stated that the assessment is thorough and extensive and in accordance with the best available modern standards. The Department will not register a product that can be shown to pose hazards to the environment or to human health under prescribed conditions of use. Consequently, the registration procedure should ensure a high degree of safety.

Nevertheless, the role of the Federal Government in this matter is sometimes criticized and misunderstood.

One frequently heard objection is that the responsibility for registration rests with the Department of Agriculture, which is perceived by many to have a bias towards increasing productivity at the possible expense of the preservation of the natural environment. At public hearings, this impression is sometimes reinforced by the spirited defense representatives of the Department of Agriculture give of their decision to register the products. On such occasions, they naturally, and unavoidably, appear to be on the side of the pesticide manufacturers. It should be emphasized, therefore, that in matters of public health the Pesticide Division of the Department of Agriculture allows itself to be guided by the Pesticide Division and the Foods Directorate of the Department of Health and Welfare. Close contact is also maintained with the Department of Fisheries and Oceans and the Department of the Environment in matters relating to the preservation of the natural environment.

A serious difficulty may be encountered in the precise interpretation of what the registration by the Federal Government guarantees concerning the safety of a registered pesticide. Some may draw the simple conclusion that the pesticide is safe, that there are no hazards to human health and no unacceptable consequences for the environment, provided that the pesticide is used in accordance with the label instructions. Others may note that the Federal Government in registering a pesticide does not, and indeed cannot, guarantee its safety under operating conditions. Some people conclude, therefore, that the safety of the pesticide is still, to a greater or lesser degree, suspect since, after all, a pesticide is a toxic chemical, designed to destroy living organisms.

The problem here is that safety is a relative concept, while the act of registration is a categorical response, a decision that creates a black and white situation with respect to safety.

The representatives of the federal departments freely admitted at the hearings that absolute safety assurance is not obtainable and no registration official can provide infallible assurances of safety. They spoke of the need for reevaluation because previously registered pesticides may fall behind more modern registration standards. They mentioned that in reevaluation "... it is generally not economical for the industry to produce quantities of expensive data. The problem then becomes one of balancing benefits against data gaps as much as against identified risks..." (Hollebone). They spoke of a "... reasonable degree of safety ..." (Ritter). They admitted that it is entirely possible that there may be "outliers" in the population, persons who happen to be much more sensitive to a particular chemical than one would anticipate on the basis of the investigations. They also granted that "... to model potential human hazards for a community of a million people from the results of 50 (test) animals ... leaves something to be desired ..." (Ritter).

Statements like these, and others that could be cited, support the contention that federal registration does not provide a guaranteed "safe" classification, nor does it eliminate the need for caution and for discrimination in the use of insecticides, particularly when the exposure of the general public is a factor to be considered.

On the other hand, the representatives of the federal departments plainly said that, in their opinion, when used as registered, the pesticides "are consdered to be safe for the conditions of use." They would not differentiate between approved insecticides on the basis of their relative safety. When asked to do so, they simply stated that they were not aware of any known health or environmental problems that would be associated with the use of any of the registered insecticides provided label instructions were followed.

It appears, therefore, that there is no clear and simple answer to the question of what registration means with regard to the safety of a pesticide.

On the one hand, the degree of safety is such that extensive and thorough theoretical and experimental investigations, in accordance with the best methods available at the time of registration, have failed to indicate hazards to human health or to the environment under prescribed conditions of use. Indeed, the degree of safety goes beyond that. The pesticide is also tested for conditions that are definitely not recommended but that conceivably could occur under operational conditions of use. A margin of safety is thus obtained. In addition, by continual monitoring and review of new information, a concerted effort is made to identify health problems that might have escaped detection under earlier investigations that were less thorough and complete than the standard investigations presently in use. One may, therefore, anticipate that the probability of adverse effects under prescribed conditions of use is minimal.

On the other hand, our knowledge of the effects of chemical insecticides in a real life situation is incomplete. It must be anticipated that in a general population, comprising the very young as well as the very old, the healthy and the infirm, people with normal as well as with defective metabolism, the sensitivity to insecticide or its degradation products will vary widely. The possibility of adverse effects following widespread dispersal of the insecticide, even in small quantities, may be very slight but it is neither negligible nor imaginary.

It can be concluded, registration means that, in the opinion of responsible and knowledgeable officials of the Federal Government, the residual risk has been reduced to the point that it should not preclude the use of the pesticide when label directions are followed exactly. But federal registration does not eliminate all risk. Neither does it relieve provincial and municipal governments from the responsibility for the safety of persons that may be exposed to the chemicals used in an insect control program.

## 2-3. Propoxur (e.g. Baygon)

Propoxur is a carbamate which has proven to be effective against adult mosquitoes and blackflies. In a variety of formulations, primarily under the trade name Baygon, it will rapidly kill these insects.

The insecticide is dispersed by thermal foggers or cold foggers (ULV). In thermal foggers, the insecticide is mixed with diesel oil, which is heated and dispersed by means of an air blast as a dense cloud. Droplet sizes are variable and range from 5 to 100 microns. The modern cold foggers use specially designed nozzles to control the droplet size within a narrower range. The average size droplet is chosen to maximize the efficiency for the particular application. In addition, these applicators do not need diesel oil as a carrier and use the insecticide in much higher concentrations and lower volumes than in thermal foggers. For this reason, they are referred to as ultra low volume (ULV) applicators.

Formulations are available for both aerial spraying and ground fogging. The recommended rates of application for ground fogging amount to rates of 17.5 - 27.5 g ai/ha (grams of active ingredient per hectare). For aerial spraying, the recommended rates are much higher, 32.5 - 125 g ai/ha depending on the density of the vegetation. Aerial spraying is done at a considerable height. During the emergency spraying programs in Manitoba in the years 1975, 1977, and 1981, the rate of aerial application was 53 g ai/ha using ULV equipment.

Unlike some other insecticides, Baygon retains its effectiveness for all temperatures at which mosquitoes are active. This is an important feature for Manitoba where cool nights may prevail during the period that application is desired.

Compared with other commonly used insecticides, Baygon is not considered to be a persistent chemical in the environment and it is not accumulated in living organisms. The persistence of residues in the environment is variable and dependent on a multitude of conditions; it may range from a few hours to several months. Baygon can be used at much higher concentrations, for example, as a residual spray in animal housing and when so used mosquitoes and other insects may be killed by the propoxur vapour for periods up to several months following application, dependent on the concentration of the spray, the nature of the surface sprayed, and the environmental conditions.

Baygon may cause damage to plants, but only at concentrations exceeding the levels recommended for biting fly control.

As noted on the label, Baygon is quite toxic to bees although measures may be taken to reduce the adverse effects of spraying and fogging programs. Its effect on other beneficial invertebrates is laragely unknown. It is probably limited primarily by the breakdown of the product in the environment, since propoxur has been shown to be toxic to a wide variety of pests. Some mosquito strains are resistant to propoxur as are some other insect species. At the present time, it does not appear likely that the primary vector or carrier of the western equine encephalitis virus, the Culex tarsalis mosquito, will develop resistance against the insecticide as a result of the limited exposure to propoxur, to date.

Numerous studies have been made of the effect of propoxur on birds. Most are based on acute oral ingestion or ingestion of contaminated feed. Insufficient data are available on the hazards of dermal exposure and of inhalation of the insecticide under field conditions. Rough calculations based on approved droplet concentrations and probable exposure time would indicate that mosquito control programs are unlikely to have a significant detrimental effect on the bird population.

With regard to the effect on aquatic ecosystems, it must be recognized that contamination of surface waters cannot readily be avoided with fogging or aerial spraying operations. The potential hazards that must be considered are, first of all, the toxicity with respect to fish and other aquatic organisms; secondly, the persistence of the insecticide in the water; and thirdly, the tendency of a compound to accumulate in tissue.

Fish can be killed by propoxur in the water at concentrations varying from one to fifty milligrams per litre. But during the emergency aerial spraying program in Manitoba in 1981, the concentration in some of the water reservoirs was reported to be only in the order of 0.002 milligrams per litre. Other studies also indicate that it is very unlikely that the rates used in mosquito control would kill fish.

The situation is quite different for the aquatic insects the fish feed on. These are much more sensitive to propoxur and may well suffer severe setbacks as a result of aerial spraying or fogging resulting in an offtarget drift of the insecticide.

Propoxur is rather persistent in pure water and quite persistent in an acidic aquatic environment. Microorganisms appear to be able to metabolize propoxur which reduces the persistence in natural waters. Even so, the half life of the chemical may be in the order of 9 days. Shorter half lives have been observed when microorganisms had been grown in water containing Baygon. This apparently increased their ability to metabolize the propoxur.

The bioaccumulation of propoxur in the aquatic environment is quite small compared to DDT. The product is far more biodegradable and has less tendency to accumulate in the tissues of the organisms.

With respect to the toxicity to mammals, including man, acute toxicity must be distinquished from long-term toxic effects.

Propoxur is a moderately toxic carbamate insecticide for laboratory animals and man. Field studies have shown that occupational workers are probably the highest risk group. However, acute toxicity is not considered to be a danger to mammals and man as a result of the relatively low dosages that will kill mosquitoes and that are sprayed into the environment, for this purpose, during mosquito adulticiding programs.

Many studies have been performed to determine the effects of various exposure levels on laboratory animals, primarily rats, mice, dogs, cats, and rabbits. All major exposure routes have been examined; acute oral, dietary, dermal, ocular, and inhalation. In addition, some information of acute toxic effects on man has become available through a limited number of studies on volunteers, from accidents, from studies on people living in Nigerian villages where dwellings were sprayed with Baygon in a malaria eradication program, and from a suicide attempt. As a result, the acute toxicity on normal individuals is well-known and is reflected in the product label instructions, which are designed to prevent harmful exposure levels under operating conditions. It should also be mentioned that the observed acute toxic effects are reversible and that, provided the organism survives, the symptoms of propoxur poisoning tend to disappear within 24 hours. Thus, there need not be a high level of concern about acute toxic effects on normal individuals, provided label instructions are precisely followed.

The long-term effects are of greater concern because much less is known about them. Long-term toxicity due to dietary exposure has been studied fairly extensively in laboratory animals. As expected, levels could be identified at which symptoms of carbamate poisoning appear. These findings are of primary importance to individuals directly involved in the spraying or fogging programs who may be repeatedly exposed to the insecticide. It is unrealistic to assume that label instructions are completely adequate under the widely varying conditions people have to cope with during fogging and spraying operations. In addition, instructions may not always be followed. For this reason, it is essential that any staff involved in the operations are examined regularly for signs of undue exposure. This is is the practise in the City of Winnipeg Insect Control Branch.

Public concern about long-term effect focusses mainly on the possibility of carcinogenicity, teratogenicity and mutagenicity. Studies involving a wide variety of experimental protocols have failed to show these effects for propoxur itself. But when propoxur reacts with nitrite under acidic conditions, a new compound, nitrosopropoxur is formed. Nitrosopropoxur is mutagenetic and carcinogenetic.

The possibility that nitrosopropoxur can be created as the result of the dispersal of propoxur has given rise to serious controversies.

The 1982 National Research Council of Canada bulletin on propoxur states that the nitrosated insecticide was shown to be mutagenic and tumoragenic in a number of systems. This publication recommended that a committee be set up at the federal level to improve experimental protocols and to organize the investigation of the effects of the emergency spraying of propoxur and other possible alternative pesticides. It also recommended that studies be carried out to determine the toxicological significance of changes in electrocardiogram patterns and behaviour observed in experiments with rats and monkeys due to exposure to carbamates at dosages lower than those usually associated with cholinesterase depression or signs of carbamate toxicity.

Nitrites are present in foodstuffs, water and soil and significant amounts of nitrosopropoxur can be produced under conditions similar to those existing in the human stomach. Recent experiments at the University of Western Ontario by Dr. J. E. Cummins also appear to indicate that nitrosopropoxur can be formed upon exposure to $NO_2$ gas, especially at $NO_2$ levels found in diesel exhaust or cigarette smoke. The carcinogen could presumably find its way into the human body by inhalation of polluted air or by dust particles to which it could be bound. Chemicals similar in structure to nitrosopropoxur have been found to cause birth defects in laboratory animals.

But the fact that nitrosopropoxur can be generated under laboratory conditions does not necessarily mean that it will form under natural operating conditions to a degree sufficient to cause adverse effects, nor that it will persist long enough to cause harm. The representatives of Chemagro, the company that manufactures Baygon, provided considerable argument in favour of the position that the risk associated with the possible formation of nitrosopropoxur is a theoretical, rather than a practical risk. Their position is based on the following:

1. Carbamates are not the only compounds that can be nitrosated to form carcinogens. Amines from different sources form nitrosoamines that are carcinogenic and are implicated in birth defects. Nitrosoamines are formed much more rapidly. Even if nitrosopropoxur was formed, it might not contribute significantly to the risk of cancer.

2. Nitrosopropoxur is unstable in sunlight and is also degraded when applied to the soil under dark conditions.

3. Experiments using human gastric juice as a medium for the nitrosation to take place in, failed to produce detectable amounts of nitrosopropoxur.

4. Experiments on mice failed to produce nitrosopropoxur when fed Baygon in combination with nitrite.

The Pesticide Division of the Department of Health and Welfare appears to agree with the position that the danger of the formation of nitrosopropoxur has not been demonstrated sufficiently to take regulatory action. A recent (1982) study of propoxur by the Associate Committee on Scientific Criteria for Environmental Quality of the National Research Council Canada has not taken sides in this controversy. It notes that, "An overall assessment of the possible effects of nitrosopropoxur in humans, as a result of current propoxur use patterns in Canada, could be made if adequate data bases were available on the dietary concentrations of propoxur and nitrite, the kinetics of formation and degradation of propoxur under physiological and environmental conditions, and the carcinogenic risk of nitrosopropoxur to laboratory animals. Unfortunately, these data bases are not available for the evaluation of propoxur or any of a large number of pesticides which may undergo nitrosation after release into the environment. It is at present not even certain that the contribution of nitrosated pesticide would significantly influence the carcinogenic risk associated with the nitrosation of natural products, since a wide variety of secondary, tertiary and quaternary amines are also susceptible to nitrosation."

Given this assessment of the situation by the N.R.C.C. Associate Committee, the position of the Federal Government with regard to registration is understandable. But the Associate Committee did not belittle the potential hazard of nitrosopropoxur. The very uncertainty is another good reason for caution and discrimination in the use of propoxur for mosquito control programs.

The Clean Environment Commission has concerns about the long-term toxicity of propoxur residues and breakdown products as expressed by the National Research Council and Prof. J. E. Cummins. It does not, however, have the technical resources or the scientific background necessary to provide a definitive answer to the concerns raised. It, therefore, concurs with the National Research Council recommendation for further study and, therefore, recommends a scientific investigation by federal and provincial health and environment authorities of the long-term effects of propoxur residues and breakdown products from both aerial and ground based mosquito adulticiding programs. The results of such a study would be expected to provide authoritative reassurance as to the safety of the use of Baygon or, alternatively, the extent of any hazards that may exist.

The technical facts and the descriptions of the effects of propoxur which are contained in this section are largely drawn from the 1982 Publication No. NRCC 18572, of the National Research Council of Canada, entitled "Effects of Propoxur on Environmental Quality with Particular Reference to Its Use For Control of Biting Flies". This publication was taken as an exhibit during the hearings.

## 2-4. Malathion

Malathion, an organophosphorus insecticide, is a product which is toxic to insects but has low toxicity to mammals. It is available in a variety of formulations principally under the trade name Cythion.

Malathion may be used as both a mosquito larvicide or adulticide. As a larvicide, malathion may be applied in sufficient oil or water solution for even coverage from an aircraft or ground application to mosquito breeding areas at rates up to 550 g ai/ha. This is a fairly high rate of application compared to other larvicides such as temephos. Malathion has a short residual action being less than 3 days in water. Malathion is also registered as an adulticide and may be used as a spray, mist, or thermal fog at rates up to 550 g ai/ha. Malathion is a good killer of mosquitoes with short residual control (2-3 days) and is most effective at temperatures over 18°C.

In general, malathion provides a low degree of hazard to the environment. In a soil environment, it has been found that malathion degrades rapidly and moves little through the soil column. In the atmosphere and on organic or inorganic surfaces, ultraviolet light degrades malathion to less polar compounds (the subsequent breakdown products have not been identified). Soil microorganisms readily degrade malathion with residues disappearing within a week. In that malathion is biodegradable and application rates are low, harmful residues on plants do not occur and the insecticide does not accumulate in the food chain. Evidence of malathion's low phytotoxicity is its use on a wide variety of ornamental and food plants. Plant toxicity, if any, is usually associated with the oil carrier. Activity persists only a short time in aquatic habitats or in wet soil conditions. In that malathion becomes bound to soil particles readily, movement of the insecticide in surface waters is minimal. In addition, the peak runoff (spring time) and applications of malathion do not coincide. Some small sensitive fish experience direct toxicity in waters treated with this insecticide. Most fish species, however, including sensitive ones, are usually unaffected when the waters are not sprayed directly. Malathion is generally rated safe for use with birds on the wing and in fact it is registered as an insecticidal dust for direct application on chickens, ducks, geese, and turkeys to control certain lice, mites, and ticks. Mammalian wildlife have shown no apparent effects of malathion in large treatment areas. Malathion can destroy bees as a result of poor application procedures.

Malathion has been noted to have an unusually low degree of toxicity to man. In most countries, it is an acceptable chemical for the control of human ectoparasites such as lice. Malathion is less inhibiting to cholinesterase than most other members of the same class of insecticides.

Although it is one of the least toxic of the commonly used insecticides when used correctly, care must be taken to follow label instructions. It has been one of the most widely used chemicals in mosquito control programs particularly where exposure of persons and domestic animals occur in the treated area. Of the 23 communities or park areas having Clean Environment Commission orders respecting mosquito control programs or operating under Section 14.1 of The Clean Environment Act in Manitoba, 14 of these areas, including the City of Winnipeg, are authorized to use and continue to use malathion. This use is principally as an adulticide in ULV sprays. As noted earlier, one of the principal reservations with respect to its use is its ineffectiveness at temperatures less than 18° to 20°C. In that much of the adulticiding occurs during August, many evenings when mosquito activity is at its peak have temperatures below the range of effect of malathion.

## 2-5. Methoxychlor

Methoxychlor is a chlorinated hydrocarbon which appeared in the late 1940's when DDT was an accepted insecticide. Although the two chemicals are structurally related, methoxychlor is a relatively safe insecticide. It is available in a variety of formulations.

Methoxychlor is registered for use as both a mosquito larvicide and an adulticide; however, its principal use in mosquito control programs is as an adulticide. The insecticide is applied as a dilution with fuel oil in a thermal fogging unit at application rates of 35-70 g ai/ha. Methoxychlor has been used for mosquito abatement in the Winnipeg area since 1970. As the thermal fogging units break down and are replaced by ULV units, less methoxychlor is used for mosquito control.

Methoxychlor is relatively nonpersistent and does not accumulate to a significant extent in tissues of animals. Accumulations may occur in the tissues in some animals such as snails, mollusks and crustacaens (methoxychlor metabolism is slower than in some higher animals). Fish may concentrate methoxychlor; however, the residue is lost soon after exposure ceases. Methoxychlor has low toxicity to mammals and birds, but is highly toxic to fish. In that methoxychlor is toxic to insects, it is toxic to bees and losses may result in the event of poor application procedures.

The lack of prolonged persistence, together with its failure to accumulate in most biological tissue makes methoxychlor an attractive mosquito adulticide. Apart from the City of Winnipeg, a number of areas in Manitoba have utilized methoxychlor as a mosquito adulticide. As the thermal foggers fall into disrepair, replacement is taking the form of ULV nonthermal generators which are easier to operate and more precise of control. This has resulted in a reduction in the use of methoxychlor.

## 2-6. Resmethrin

Resmethrin is a synthetic pyrethroid which is registered for use as a mosquito adulticide utilizing ULV equipment. This chemical was not available in Canada before 1979. The maximum application rate is listed as 7.5 g ai/ha. Limited field trials undertaken by the City of Winnipeg in 1982 were not successful due to application difficulties. According to one Minnesota report, resmethrin is a relatively safe insecticide. It degrades rapidly in the environment, has a low mammalian toxicity, and a low toxicity to birds. The 1982 Pesticide Dictionary indicates that resmethrin is toxic to fish. This opinion was confirmed by technical representatives from Fisheries and Oceans Canada at the mosquito control hearings. Apparently, the synthetic pyrethroid as a group, including resmethrin, are extremely toxic to fish.

There is an argument, however, that resmethrin is bound to soil particles and remains in that form unavailable to the fishery. This phenomena would limit the fish toxicity concerns to that of the direct application of resmethrin to the waters in question. There is no doubt that, since resmethrin has only been used for a short time in Canada and on a limited basis, the health effects would probably be reexamined very carefully by the Health Protection Branch of Health and Welfare Canada if large-scale applications were contemplated.

## 2-7. Temephos (e.g. Abate)

Temephos or Abate, as it is commonly known, is an organophosphorus compound developed especially for the control of mosquito larvae. It is registered for mosquito control in Canada at an application rate ranging from

55 g ai/ha to 550 g ai/ha with the latter rate being that prescribed for heavily polluted waters. Temephos has been used in public health programs throughout the world for nearly 20 years. Temephos has as its main application the destruction of immature larvae breeding in snow melt water in and around woodlots and in drainage ditches. Residual control ranges up to 4 days. Generally one annual application suffices.

Temephos has had few ill-effects on most nontarget organisms common to mosquito larvae sites and as a matter of fact is restricted in toxicity to a narrow range of insect groups. Temephos is ranked very low in terms of toxicity to mammals albeit temephos is a cholinesterase inhibitor and in a concentrated form is potentially harmful if mismanaged by operators. Temephos is ranked low in terms of bird and fish toxicity. Temephos does not accumulate in animal tissues.

## 2-8. Chlorpyrifos (e.g. Dursban)

Chlorpyrifos or its common name Dursban is an organophosphorus broad spectrum insecticide which will control insects in soil, water, air and on plants, animals and other treated surfaces. The compound, however, has high biological activity against both larval and adult mosquitoes. It is registered for use in Canada for both larviciding and adulticiding. As a larvicide, the application rate is limited to 27.5 - 55 g ai/ha with the high rate being used only under circumstances of high vegetative cover or organic content. In the City of Winnipeg, a granular formulation is applied both aerially and by ground crews. It is used extensively during warmer and wetter summer months due to its longer residual activity in mosquito breeding sites (up to 2 weeks of effective control). It is also effective against all of the species of mosquitoes commonly found in Manitoba.

In terms of the environment, chlorpyrifos is a relatively safe compound. Studies have shown that chlorpyrifos has marked evidence of volatility and is lost from soil principally by this route. In terms of degradation in water, most of the larvicide is absorbed to detritus and suspended matter on which mosquito larvae feed. Chlorpyrifos has no phytotoxicity at rates considerably in excess of those used in mosquito control. Fish are able to metabolize chlorpyrifos residues quite quickly and show no bioconcentration after the first few days. A limitation of the registration is that chlorpyrifos be used only in water where outflow is confined beyond the limits. Also, the higher application rate (55 g) is to be used only if there is no fish. In mammals and domestic birds, chlorpyrifos is metabolized or excreted rapidly. Although chlorpyrifos is a cholinesterase inhibitor, no ill-effects have ever been observed in exposed humans during application operations in accordance with label instructions.

## 2-9. Mineral Oil (e.g. Flit MLO)

At present, Flit MLO is the only mineral oil product registered for use as a larvicide and pupicide.

Flit MLO is a highly refined mineral oil. As the commonly used larvicides are relatively ineffective against the nonfeeding or pupa stage of the mosquito, Flit MLO is used. The product is applied to the surface of pools using ground based vehicles. Control is difficult to achieve in densely vegetated areas. Also, in large surface water areas, the product tends to be wind blown. Another shortcoming is the short effective life of the material. In that the effect may only last up to 48 hours, retreatment may be necessary. Application rates vary from 1 to 5 gallons per acre of water surface.

Flit MLO presents little risk to either the operator or wildlife. It will destroy beneficial insects which, like the mosquito larvae, come to the surface for air. Little or no phytotoxicity has been observed with the use of Flit MLO. The City of Winnipeg uses Flit MLO effectively in temporary breeding sites adjacent to truck gardens and apiaries, in sites supporting valuable fish or waterfowl and in those sites in which pupae are present in high numbers.

## 2-10. Pyrethrin (e.g. Pyrethrin Tossits)

Pyrethrin Tossits are derived from pyrethrum, the dried flowers of Chrysanthemum cinerariaefolium. In some parts of Asia, powders of these flowers have been used for louse and flea control for almost 2 centuries. In that natural pyrethrins are costly, synthetic pyrethrins have been developed. The Tossit capsules which are registered for use for the control of mosquito larvae contain 1% pyrethrum and 10% of a synergist, piperonyl butoxide.

Capsules are applied at a rate of 1 per 100 square feet of water surface (6 inches deep). Pyrethrins are contact insecticides which act rapidly on an insect's nervous system. The City of Winnipeg has reported a number of disadvantages in using the capsules in that they sometimes fail to rupture in a matter of minutes as required and fail to disperse evenly over the surface of a pool especially in the presence of emergent vegetation. Pyrethrins are recognized as being potentially toxic to fish, but do not accumulate in fish tissue. Pyrethrins generally have a low toxicity rating with nontarget organisms. In that the pyrethrin is encapsulated, their use presents no risk to the applicator. Because of their cost and the disadvantages cited, the City of Winnipeg limits the use of the Tossits to small breeding sites whereas Tossits represent a significant portion of the mosquito larviciding program in Thompson.

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# SECTION 3

# CONTROL OF NUISANCE MOSQUITOES

## 3-1. Introduction

Mosquitoes are an annually recurring nuisance throughout Manitoba. Their numbers vary widely in response to shelter and breeding habitat provided by vegetation and drainage conditions. For this reason, some areas of Manitoba have a much worse mosquito problem than others. Northern Manitoba, and other areas where bush and wet lands are prevalent, are particularly amenable to the development of high populations of mosquitoes and other biting insects. The area surrounding the City of Winnipeg may also be a problem area because the flat landscape and underlying relatively impermeable soils, result in widespread ponding after rainfall. This provides ready breeding ground for the rapid development of recurring, new generations of mosquitoes.

The tolerance people show towards this pest also varies widely. But periodic outbreaks are triggered in all locations by rain and humid weather that push mosquito numbers and aggressiveness far beyond established tolerance levels. Large numbers of Manitobans place a great deal of emphasis and priority in their lifestyle, on outdoor activities during the relatively short Manitoba summer season. This outdoor enjoyment is seriously affected and curtailed by heavy concentrations of so-called "nuisance" mosquitoes. It is no wonder, therefore, that there is a strong public demand in this province for chemical control of nuisance mosquitoes.

Mosquitoes are, of course, not only a nuisance. Certain species are also responsible for the transmission of western equine encephalitis in this province. Mosquito bites can also cause allergic reactions in humans which vary from insignificant to substantial. Scratching of mosquito bites may result in infections, especially with children. Furthermore, mosquito species that are common in Manitoba can transmit heartworm disease to dogs. This is a serious disorder caused by nematodes in the bloodstream, which eventually block the pulmonary arteries and cause death in dogs.

It is essential to separate the nuisance aspect of mosquito control from the health aspect for these are two distinct and different issues.

As far as western equine encephalitis is concerned, the mosquito vector known to transmit the virus in Manitoba is the Culex tarsalis. This is primarily a bird blood feeder. It has a different distribution in time and place than the primary nuisance mosquitoes; it uses different breeding habitat.

It is true that warm, humid weather promotes both the outbreaks of Culex tarsalis and of the nuisance mosquitoes. But the arbovirus responsible for western equine encephalitis is not always present. The nuisance caused by mosquitoes may, therefore, be severe without there being any significant risk of western equine encephalitis. Whether or not this health risk is present can be determined reliably by the arbovirus surveillance program in the Province.

Control methods also differ. Outbreaks of western equine encephalitis are episodic and entail serious health risks. Mosquito control, for this purpose, may require extensive and centrally directed aerial spraying programs. Control of nuisance mosquitoes requires continuing and detailed programs aimed primarily at those mosquito types that cause the greatest trouble.

It would, therefore, be irresponsible to justify the control of nuisance mosquitoes in part by referring to the danger of western equine encephalitis, as sometimes happens.

Concerning the other health aspects of mosquitoes, referred to above, it should be mentioned that heartworm disease is not a disease likely to be contracted by humans. In dogs, it can easily be prevented by proper medication. There is no intention of minimizing the allergic reactions or the infections that may result from mosquito bites. It should be understood that these minor health problems are included when this report speaks of the nuisance caused by mosquitoes.

Nuisance mosquito control programs have been criticized from two aspects: safety and efficacy. Chemical mosquito control unavoidably entails widespread dispersal of insecticide into the environment; this involves exposure of nontarget species, including humans, to the insecticide. In addition, reducing mosquito numbers effectively requires considerable expertise, expensive equipment and suitable weather conditions.

Operationally, the conditions for effective control may not always be available. The question thus arises whether the control programs are effective enough to justify the risk associated with the dispersal of insecticide and the cost to the taxpayer. The two aspects of chemical control, safety and efficacy, are examined in detail in this section.

There is a third aspect of nuisance mosquito control that must receive attention, namely, that of regulation. The dispersal of any contaminant into the environment by municipal authorities is regulated by The Clean Environment Act. This Act allows a municipality two options. The municipality may apply to The Clean Environment Commission for an order. The Commission will then prescribe by a formal order, in detail, what control methods are permitted and what conditions and limitations must be met. The municipality may also proceed without reference to The Clean Environment Commission, provided that the control program does not affect the environment beyond the municipal boundaries. With the second option, the municipality must file an environmental impact statement with the Environment Department. This must outline the program and its possible environmental effects.

The intent of the second option is to allow a municipality to judge for itself whether the benefits of a control program outweigh the risk to the environment or to human health within its own boundaries. The Act does not require approval of the program or of the impact statement by Provincial authorities; however, it has the approval of the elected officials of the municipality. Presumably, the Environment Department could voice warnings or objections. The Department, however, has taken the attitude that it will not object to any program in which a federally registered chemical is to be used for the intended application in accordance with the label instructions.

The question has been raised whether the second option adequately meets the need for public participation and whatever responsibility the Province has for the environment and for public health. The matter of regulation and possible legislative changes are dealt with more fully in Section 5: "Legislative Changes."

Control of nuisance mosquitoes is dealt with under three headings: "Effectiveness of Nuisance Mosquito Control Programs", "Safety of Nuisance Mosquito Control Programs" followed by the third part dealing with conclusions and recommendations concerning nuisance mosquito control programs.

## 3-2. Effectiveness of Nuisance Mosquito Control Programs

### 3-2-1 Methods of Control

In principle, there are three methods of reducing the numbers of mosquitoes. The first aims at preventing their propagation, the second at destroying the larvae and pupae, the third at killing adult mosquitoes.

All mosquitoes need an aquatic environment, in the form of a stagnant pool, in which the eggs hatch, the larvae develop into pupae and the pupae into adult flying mosquitoes. Without this they simply cannot propagate. It follows that reducing the number of stagnant pools available to the mosquitoes is an effective way of reducing mosquito numbers. It is also a preferable way of dealing with the problem compared to chemical control of adult mosquitoes. Unfortunately, it does not present a total solution to the mosquito problem.

Some mosquitoes breed in permanent ponds. Others, for example the Culex tarsalis, which transmits western equine encephalitis virus, have a preference for waterfilled containers, such as discarded cans, old tires, stock watering troughs, rain barrels, etc. But the mosquitoes that cause the greatest nuisance are the so-called flood water mosquitoes. These lay their eggs in moist soil where subsequent inundation by melting snow or rain will create shallow pools of stagnant water in which the eggs hatch and the mosquitoes develop.

There are two types of flood water mosquitoes, the spring breeding and the summer breeding mosquito. The spring breeding mosquitoes lay their eggs in the summer but these hatch the next spring when the snow melts. The larvae develop relatively slowly in the cold snowmelt water. Many communities in Manitoba, however, are surrounded by poorly drained, bushy terrain where snowmelt pools persist long enough to raise the spring breeding mosquitoes in great abundance. In those communities, this rather long-lived mosquito is the major nuisance type mosquito. They are relatively sensitive to dry atmospheric conditions and when the weather is dry and sunny they hide mostly in the bush and in tall grass. During humid days, however, and in the evening, they make their presence felt.

Summer breeding mosquitoes may produce several hatches in each season. The eggs lie dormant in road and railroad ditches or other poorly drained areas until they are flooded after a heavy rain. Because of the higher temperature, the summer breeding mosquitoes develop much faster than the spring breeding types. Depending on the weather, they may need one to two weeks, a condition often available to them after a heavy summer rain. Eggs can remain dormant for a year or longer.

The combination of flat terrain, heavy soil, periodic heavy summer rainfall and the availability of blood meals, which the females need for the development of the eggs, makes the summer breeding flood water mosquito the major nuisance type in the City of Winnipeg.

Mosquitoes are quite mobile. They are attracted by light and smell and also move with the wind. Tests have shown that they may travel several kilometers in one night. Thus they readily invade any human habitat within several kilometers of their breeding grounds. Many millions of mosquitoes can be produced in what may seem to be rather insignificant pools.

From this description, it can be seen that reducing mosquito breeding habitat is not a completely feasible solution to the nuisance problem. It would require a major and extensive landscaping effort, entailing major costs, to be effective.

Nevertheless, it must be recognized that many mosquito breeding areas have been created by the construction of roads and railroads. With a little more foresight and care during the design and the construction, adequate drainage could have been provided at little or no extra cost. This should be kept in mind when new works and renovations are being planned and a concerted effort should be made not to create new, or to maintain old, mosquito breeding habitat in the vicinity of populated areas.

### 3-2-2 Larviciding

Larviciding, including the destruction of mosquito pupae, is an essential component of any nuisance mosquito control program. A single female mosquito may lay several hundreds of eggs. In slightly moist soil, these eggs may remain dormant for many years. Thus even small pools may produce vast numbers of adult mosquitoes under favourable conditions. During their larval stage, the mosquitoes are concentrated in, on the whole, shallow and stagnant pools of water where they are quite vulnerable to chemical attack. This then is the time when the control program can be the most effective.

The efficacy of larviciding is borne out in practise. Experiments with light traps within and outside the larval control zone of the City of Winnipeg showed that, following a mass emergence of mosquitoes triggered by weather conditions, the numbers outside the control zone were roughly ten times those within the control zone. This difference decreases in time because of mosquito dispersal and wind drift. But it remained high for several weeks.

The experience in the City of Brandon has been similar. An effective larviciding program has eliminated, for the last five years, the need for fogging of residential areas. Only parks and recreational areas were sprayed with ultra low volume machines. On occasion, large numbers of nuisance mosquitoes did appear in the City. These invasions were attributed to strong winds that blew the mosquitoes in from several kilometers away. It was claimed that within three days these populations disappeared. It was, therefore, not considered to be necessary to attempt their elimination by residential fogging.

Representatives of Ontario, Saskatchewan, and Alberta confirmed the high efficacy of larviciding programs in their provinces, although it was admitted that these programs did not prevent the occasional outbreak of large numbers of nuisance mosquitoes.

Instituting an effective larviciding program, however, is not a simple matter. It must be properly and carefully planned and executed, which requires expert professional help and considerable labour.

A larviciding control program must start with the mapping of mosquito breeding sites in the larval control zone. Locating these sites usually requires repeated surveys over a number of years. The larval control zone should extend as much as five miles beyond the area to be protected, otherwise the influx of mosquitoes from untreated areas will be too great and too rapid. Some sites are far more productive than others because of the vicinity of cattle or other sources of blood meals and should be so identified. In addition, it is necessary to identify sites that should not be treated because of possible overflow into sensitive waters or because of the use that is made of the water, e.g. for livestock operations.

Breeding sites should be treated only when the presence of mosquito larvae has been established and their development is such that the insecticide is effective. This requires systematic dipping surveys in which both numbers and stage of development can be estimated from water samples. When the larvae have developed into pupae only Flit MLO can be used effectively since no other registered insecticide is sufficiently lethal to the organism at this rather inactive stage.

The larviciding program must start early in the year to catch the spring breeding mosquitoes that hatch in the snowmelt pools. Temperature does not appear to be a factor in the hatch but subsequent development is relatively slow in the early spring. This allows time for confirmation of the presence of larvae and for their treatment.

Summer breeding mosquitoes are more difficult to control by larviciding because their development from the egg to the adult is much more rapid. Under favourable circumstances, it may take less than a week. In addition, a series of hatches may be triggered by summer rainfalls. This may put a severe strain on the available manpower and equipment, especially if the rains have reduced the accessibility of the breeding sites. Aerial applications by means of a helicopter is then the only practical way of treating large areas.

Insecticides available for larviciding are Malathion and Methoxychlor, the newer organophosphates temephos (Abate), chlorpyrifos (Dursban) and fenthion (Baytex), the natural pyrethrin compounds (Ambush and Tossits), the growth regulators methoprene (Altosid) and diflubensuron (Dimlin), and the mineral oil Flit MLO.

The newer organophosphates have the advantage that they require much smaller rates of application than Malathion and Methoxychlor. For early spring application, temephos, e.g. Abate, is often chosen because it rapidly breaks down and disappears within two or three days. It is more toxic to mammals than malathion but, unlike malathion, it is effective in cold temperatures.

In the summer, it is often desirable to have an insecticide with a with a longer residual action, such as chlorpyrifos, e.g. Dursban, which remains effective up to two weeks. This will ensure that mosquito larvae which hatch a little later, will also be destroyed. A similar effect can be obtained by using slow release formulations, for example, Pyrethrin Tossits.

The growth regulators, Altosid and Dimilin, do not kill the larvae outright but interfere with their development to the point that they do not become adult mosquitoes. Their narrow-spectrum activity has considerable environmental advantages as far as nontarget species are concerned. But, unlike the organophosphates, they do not allow an assessment of the effectiveness of the larviciding program by observing immediate larval kill.

Flit MLO is primarily a mineral oil which is dispersed over the water surface and interferes with the breathing of both larvae and pupae. The oil degrades by sunlight and water action in less than a week. Environmentally, it is a very safe insecticide; however, the required rates of application are very high: 22 to 55 litres per hectare.

From this description, it can be seen that larviciding is a major undertaking, which must be carefully planned and executed. Its success is also highly dependent on the availability of manpower and equipment at the proper time. Most municipalities would need the help of an experienced entomologist to design a program that suits their needs.

Even a well-designed larviciding program may fail to prevent nuisance mosquitoes from reaching levels many people consider intolerable. Repeated heavy rainfalls and warm weather may cause such a rapid proliferation of flood water mosquitoes that the larviciding program cannot keep up with it. This is more often the case in relatively flat terrain with impervious soils, as prevails around the City of Winnipeg, than in more rolling terrain and more pervious soils, as around the City of Brandon. In addition, strong winds may blow in mosquitoes from untreated areas. Without a larviciding program, however, the nuisance is bound to be far more severe and far more frequent.

Mosquitoes do not only breed in ditches, sloughs and marshy areas; they also breed in any container, artificial or natural, that holds water for one or more weeks. This is of significance since the Culex Tarsalis, the main vector mosquito for western equine encephalitis, appears to have a preference for such containers as breeding sites. It is obviously not practical for the municipality to eliminate all these breeding sites or to destroy the larvae in them. Larviciding chemicals are classified as restricted; this means that they are not available to the general public. The public can, however, be quite effective in emptying or removing containers where possible. Containers that cannot be emptied or removed, such as rain barrels, can be treated effectively with a little detergent. This can be of real assistance both in reducing the risk of encephalitis and controlling nuisance mosquitoes.

Particular care should be taken when treating ponds from which cattle may drink after the period of residual action mentioned in the label instructions has passed. Special attention must also be given to the treatment of waters which may overflow into the main drainage systems so as to avoid damage to nontarget species.

In summary, it may be said that larviciding is very effective in reducing mosquito numbers. But to substantially reduce the nuisance caused by the mosquitoes, the program must be both extensive and comprehensive. It requires both expert knowledge and adequate equipment. Even then it may not always be perceived as adequate in coping with the situation.

### 3-2-3 Adulticiding

Large-scale chemical attacks on adult mosquitoes became feasible a number of years ago with the advent of DDT, which proved to be a relatively cheap and effective way of controlling both larvae and adults. The success of DDT in insect control programs was due in part to its long residual action. But its persistence in the environment and its tendency to accumulate in animal tissue caused environmental concerns. And since it was implicated in reproduction problems of some bird species, it was restricted in 1969. Newer, and environmentally safer, pesticides have since then replaced it.

Several pesticides are currently registered for outdoor mosquito control in recreational and residential areas. These are: propoxur (Baygon), Methoxychlor, Malathion, chlorpyrifos (Dursban), pyrethrins, bromchlorvos (Naled), fenthion (Baytex), dichlorvos (Vapona), and resmethrin. Of these, only Baygon, malathion and methoxychlor have been used in Manitoba for adult mosquito control.

All registered insecticides break down relatively rapidly in the environment and none tend to accumulate in the environment the way DDT does. Methoxychlor persists for about two weeks, the propoxur Baygon gives residual control for about one week and Malathion is active for only two or three days outdoors.

These differences do not mean much in the control of adult mosquitoes by fogging. The rates recommended for this application are only a very small fraction of the rates recommended for residual sprays, as may be used on outdoor surfaces of farm buildings. Mosquitoes may pick up a lethal dose of insecticide by landing on a surface where fog droplets have come to rest. But the vast majority of mosquitoes require a direct hit by insecticide droplets in order to be killed. For practical purposes, one can say that adulticiding requires actual contact of the flying mosquito with the fog particles. Only occasionally are residual sprays used in parks and recreational areas when the weather is not suitable for fogging. Even then, the residual time of Malathion appears to be quite satisfactory from an environmental and health standpoint.

The requirement that a mosquito must actually be hit by insecticide droplets is basic in the understanding of the operation and its limitations.

It means, first of all, that ULV equipment is substantially more efficient than the older thermal foggers. With the thermal foggers, there is relatively little control over the droplet size, which may vary from much smaller to much larger than the optimum. The rate of application can also be much better controlled with the newer ULV applicators and there is less risk of degrading the insecticide by overheating. Thermal foggers are still being used but are generally replaced by ULV equipment, as they wear out.

Secondly, in fogging operations, the windspeed must be low; otherwise the turbulent mixing of the air will disperse the fog rapidly to higher levels above the ground and the concentration of insecticide droplets near the ground, where the mosquitoes are, will be insufficient to kill them.

Thirdly, mosquito activity is very much dependent on temperature and humidity. When the temperature drops below 10° Celsius (50° F), mosquitoes no longer fly about and fogging would be useless. But, even above 10° Celsius, the numbers of mosquitoes that are active varies considerably with moisture, wind, and temperature.

Fourthly, the mosquito activity reaches one peak for about an hour around sunset and another, a smaller one, for about an hour around sunrise. At these times, the mosquitoes migrate and are actively searching for a blood meal and there may be ten times as many mosquitoes around as during the rest of the 24-hour day. Fogging during these peak periods is obviously far more effective than at any other time. But it is not always possible or practical to fog at these optimum times.

Fifthly, the success of the fogging operation depends on how well the fog is dispersed over the area to be treated. This is affected by wind conditions but also by the available access to the area and by the obstructions created by vegetation, buildings and fences, etc.

Finally, the success of the operation is very much dependent on the skill and the expertise of the operators and the supervisors that conduct it.

Considering all these conditions it is not surprising that the success of a fogging operation, in terms of percentage of mosquitoes killed, will be highly variable.

The efficacy question is further complicated by the fact that, in the control of nuisance mosquitoes, success must be measured in terms of the objective: the abatement of the nuisance. This is invariably a matter of degree and it is not easy to set objective standards by which the degree of success can be measured.

In parks and recreational areas, it is usually possible to obtain substantial relief of the nuisance for a limited time, for example, for the duration of a fair, a performance, or a major activity. Repeated treatments may also provide an acceptable reduction in mosquito levels for activities in sports and recreation that bring people into the area for limited periods.

In residential areas, the situation is far more complex. Here people have to co-exist with the mosquitoes in the same environment; people are bitten and mosquitoes interfere with their enjoyment of their property in the short Manitoba summers. Under these circumstances, it is impossible to provide objective standards for mosquito abatement except by more or less arbitrary decision.

Programs in which insecticides are sprayed to cover residential areas for nuisance mosquito control are carried out in some communities in Saskatchewan and in northern communities of some other provinces as well as being approved for use in a number of Manitoba communities. Some large cities conduct adulticiding programs in park and recreation areas and along riverbanks; but the City of Winnipeg is probably the only major population centre in Canada that regularly conducts fogging programs in residential areas. However, it should be noted, in this regard, that Winnipeg's mosquito problems may also be much more severe than that of any other major Canadian centre.

The City of Winnipeg, undoubtedly in response to public reactions, has defined a tolerance level which is measured by an average of 25 or more mosquitoes caught in light traps during each of three consecutive nights. Adulticiding operations start when that level is exceeded and continue until the number is again below the tolerance level.

How effective is the adulticiding program in the light of this objective?

In considering the answer to this question, the mobility of the mosquitoes must be taken into account. Even though fogging may have killed all mosquitoes in a particular area, others from adjacent areas will imediately start a new invasion. If the area that was fogged is small and large infestations exist nearby, then the relief provided by the fogging may be too short to be meaningful.

Many observations bear this out. Mortality figures of caged mosquitoes placed in residential areas during fogging operations show that 80% to 100% of them may be killed under favourable circumstances. But subsequent bite counts do not show a corresponding abatement of the nuisance, except for relatively short periods.

A study conducted by Dr. R. Brust, Professor of Entomology at the University of Manitoba, for the Local Government District of Pinawa showed that with routine fogging a degree of relief was obtained in only 50% of the nights. At other times, the fogging was either ineffective or its effect was masked by natural variations due to weather conditions. When the fogging was effective, the relief it afforded did not last for more than 24 hours. This is probably quite typical for a small community surrounded by mosquito infested bush country.

In a large city, like the City of Winnipeg, the situation is different. A good larviciding program, extended over a large area, tends to keep mosquito levels down even when they do exceed the tolerance level set by the City. The available fogging equipment also enables the City to adulticide fairly large blocks each night. Thus the reinfestation can be expected to be less rapid than in a community such as Pinawa.

The City of Winnipeg conducted an evaluation of thermal fogging with methoxychlor in the summer of 1976 in compliance with the terms of an order from The Clean Environemnt Commission. Light traps and bite count stations were set up in 6 areas of the City. The fogging operation started on July 2 and lasted until July 23, 1976. City foggers made two complete circuits through the areas. With good weather conditions, each circuit should have taken 6 to 7 nights. As it was, high winds on several nights caused the first circuit to take 13 nights, while the second was completed in 8 nights. Fogging operations in each area took two or three nights to complete.

A comparison with light trap stations outside the City clearly showed that the fogging operation destroyed many mosquitoes. But the object is abatement of a nuisance and the success of the fogging must, therefore, be measured in terms of the number of days that noticeable relief is obtained that can reasonably be attributed to fogging.

This evaluation is not a simple matter. Mosquito activity varies greatly due to weather conditions and it is not easy to determine whether a reduction in bite counts is due to a reduction in numbers or in activity. In addition, mosquito numbers were consistentlylower in some areas than in others. This makes it difficult to evaluate the program in terms of the number of days the nuisance was reduced below an arbitrarily set level.

For the purpose of this report, the average bite counts per minute in the areas have been reviewed as being the most direct indicator of the nuisance. One might call this the nuisance level. It seemed to make sense, however, to relate the nuisance level in a given area after fogging to the average nuisance level in the entire city. In this way, a relative nuisance level is obtained in which the effect of the weather on mosquito activity is eliminated to a degree.

Fogging operations invariably resulted in a reduction of the relative nuisance level. The average reduction in the effective period was, of course, variable. Taking an overall average, it could be concluded that fogging reduced the relative nuisance level in the effective period to approximately 30% of the prefogging level.

It is quite difficult to set an objective criterion for the length of the effective time period, as what the situation would have been without fogging, is not known. But perusal of graphs of relative nuisance shows that after one to five days it begins to rise again and continues the random fluctuations as experienced prior to the fogging. The average effective period was found to be a little less than 3 days. This is not inconsistent with the statement of the Winnipeg entomologist who stated that, under favourable conditions, fogging of an area would reduce the nuisance level below the tolerance level by 4 days.

In summary, it may be stated that routinely conducted fogging operations will frequently be ineffective because of adverse weather conditions and/or reduced mosquito activity. Fogging operations, conducted when conditions are suitable, are capable of bringing about drastic reductions in mosquito numbers in the treated area. This makes adulticiding operations an effective method of dealing with mosquitoes in parks and recreational areas prior to scheduled events. Fogging of residential areas may bring temporary relief. In the smaller communities, where the mosquito population in adjacent areas has not been reduced sufficiently by an effective larviciding program, the reinvasion of fogged areas may be rapid, rendering the fogging ineffective as a means of abating the nuisance. When coupled with an effective larviciding program, residential fogging will bring a degree of relief in the treated areas. Based on actual bite counts, this relief is variable and diminishes in time. Even with large-scale operations, such as are conducted in the City of Winnipeg, the effect disappears within a few days. Whether or not such a program can be called effective depends on personal expectations and attitudes. It is not possible to answer this question categorically.

### 3-2-4 Biological Mosquito Control

Alternative strategies for the control of mosquitoes are being developed for several reasons. A prime reason is the desire for a more permanent form of control, which does not have to be applied anew to each insect generation. A second reason is to avoid adverse environmental effects and risks to human health that may be associated with widespread and repeated use of chemical pesticides. A third reason is to prevent or counteract the emergence of insect strains that may become resistant to chemical pesticides.

Research into biological control is conducted in two main areas. One makes use of living organisms, so called control agents, that feed on mosquitoes (predators), or that reduce their vitality (parasites and pathogens). The other aims at manipulating the target insect itself; the target insects are modified by chemistry, radiation, or genetic alteration, in a manner that is calculated to interfere with the reproductive potential of the insect population.

Predators are the most visible form of natural insect control, and are often mentioned as alternatives to chemical pesticides. They are most effective in the aquatic stage of the mosquito when larvae and pupae are then concentrated in relatively small areas and are quite restricted in their mobility compared with adult mosquitoes. They are thus easily caught and consumed by fish, beetles, caddis flies, hydra, flatworms and many other organisms. In the adult stage mosquitoes are preyed upon by some birds, by bats and by dragonflies.

The impact of predators on the overall mosquito population should not be underestimated. It is of sufficient importance to warrant careful consideration of any possible harm predators may sustain from the use of chemical pesticides in mosquito control. But predators exercise relatively little control over the population explosions which make mosquitoes such a prominent and recurrent pest. Natural predator numbers are insufficient to make serious inroads in mosquito outbreaks. Predator numbers vary in response to many factors, of which available food is only one. But peaks in predator populations seldom coincide with peaks in mosquito populations. In addition, many predators are opportunistic feeders and mosquitoes may in fact form only a small part of their diet.

Increasing predator numbers artificially poses many problems of raising and survival. Most nuisance mosquitoes are hatched in transient pools that cannot sustain a more or less permanent predator population. It seems unlikely that predators will ever become a major factor in the control of nuisance mosquitoes. On a relatively small scale, it is possible that some aquatic predators, such as the fathead minnow, will prove to be useful in reducing mosquito numbers in farm ponds or other permanent waters where larviciding with chemicals cannot be allowed.

Parasites and pathogens offer a much greater potential as control agents. There are a large number of protozoans, fungi, nematodes, bacteria and viruses, that attack mosquitoes, primarily in their larval and pupal stages. The research on these control agents is still in the early stages of investigation and experimentation. While promising results have been obtained, much more needs to be known about the effect of the control agents on the target species and on nontarget species, about the survival of the control agent in the environment, about culturing and handling techniques, about cost and about efficacy. Therefore, a detailed discussion about specific organisms under investigation is premature.

One exception is a bacteria, Bacillus Thuringensis Israelensis (BTI), has been developed and was registered in 1981 in the United States as a larvicide against both mosquitoes and blackflies. Strictly speaking, this is not a true biological control agent. The bacillus does not survive or multiply in the environment. Its effect on mosquito and blackfly larvae is based on ingestion of the spores which, in the acidic insect gut, break down and cause a severe toxic reaction that kills the larva. Its action is, therefore, more akin to that of a poison than to that of a control organism.

BTI has several desirable characteristics that make it a very promising insecticide. BTI is very effective; it produces 100% mortality at relatively low dosages. It is highly selective; while extremely toxic to mosquito and blackfly larvae, nontarget species are not harmed, with the possible exception of a few related fly species. Mortality is quick; target organisms are killed within 24 hours. BTI is not persistent; in standing water, it remains effective for up to three days, and after that it disappears. Finally, unlike other biological control agents developed for pest control, it is easily mass-produced and relatively inexpensive. BTI will probably be registered for use in Canada in the near future.

Turning now to the second main method of biological control, there are several ways of interfering with the reproductive potential of an insect population. The best known is the sterile male release technique.

With this technique, large numbers of male insects are sterilized chemically, by radiation or by genetic manipulation. They are then released into the environment, where they compete with the normal healthy males in mating with the females. Field studies have shown the feasibility of this technique in reducing the insect numbers. One of the prerequisites for success, however, is an isolated pest population. In the Manitoba situation, it is simply impossible to release enough sterilized males to significantly reduce the mating of female mosquitoes with normal male mosquitoes.

Another form of species manipulation is the development of new strains of mosquitoes that are capable of replacing the existing strains.

The aim is to develop a new strain which is either less harmful, or more vulnerable to climatic extremes or other environmental conditions that may occur from time to time. It may be possible, for example, to develop a strain of Culex tarsalis, which is not able to transmit western equine encephalitis. But the main difficulty lies in effecting a replacement of the present strains. Mosquitoes in Manitoba are spread out over vast areas; they are mobile and there are many species, at least 43 in Manitoba and 35 in the Winnipeg area alone. The conditions for successful control by genetic manipulation do not seem to exist here.

Summing up, it appears that with the exception of the use of BTI as a larvicide, biological mosquito control will not in the near future become an effective way of controlling mosquitoes.

## 3-3. Safety of Nuisance Mosquito Control Programs

### 3-3-1 Larviciding

No concerns were expressed at the hearings about the safety of properly conducted larviciding programs, except implicitly by those who voiced general objections to all forms of chemical mosquito control.

The reason for this large degree of acceptability is obvious. Larviciding is directed almost exclusively to shallow, often temporary pools of stagnant water that have little, if any, environmental value. The insecticides used are all nonpersistent; they break down within a few weeks at the most and are effectively contained in the pools during that time. Under these circumstances, exposure of nontarget species and humans is practically prevented and no adverse effects are anticipated.

This does not mean, however, that there are no hazards associated with larviciding operations. Apart from the everpresent risks involved in the handling of and working with toxic substances, the safety of a larviciding program depends on proper procedures which, in practise, may, or may not be followed.

It is of primary importance that the areas to be treated are carefully identified and mapped. A number of insecticides used for larviciding are toxic to fish. Most have a profound effect on nontarget species that play an important role in the aquatic food chain. These insecticides should not be used when there could be an overflow into a larger drainage system before the active period of the insecticide has fully expired.

Some chemicals may not be used at all in water that cattle drink from. Others require that livestock be kept away from the treated water for specified periods of time.

When the insecticide is used as a spray, there is a danger of drift which could prove fatal to bees and other valuable nontarget species.

It is true that these dangers can be minimized by proper control. Nevertheless, it is gratifying to note that the biological insecticide BTI may soon be available for use in Canada. Its selective use, in cases where chemical insecticides are undesirable, may greatly enhance the safety of larviciding operations.

It thus appears that the choice of pesticide, the timing and the method of application, the delineation of the target areas and the careful supervision of the operation are of great importance, not only for the efficacy but also for the safety of a larviciding program. Environmental safety of larviciding programs is determined by control of planning and execution of proposed programs based on expert advice.

### 3-3-2 Adulticiding

At the public hearings, many concerns were voiced about the safety of adulticiding mosquito control programs, especially residential fogging, and many attempts were made to allay fears that had been expressed. But neither sweeping condemnations of chemical pesticides, nor categorical reassurances that registered pesticides are safe, when used in accordance with label instructions, shed much light on the question of whether the practice of adulticiding should be continued.

The question before the Commission is: How safe are adulticiding programs? That question must be answered before one can consider whether or not the benefits of the programs outweigh any identified hazards.

A clear distinction must be made between fogging of residential areas and adulticiding in parks and recreational grounds. The latter will be discussed first.

Parks and recreational grounds can be treated when there are no people around. They may have to be treated repeatedly but the available access allows a thorough dispersal of the insecticide within the target area, making effective use of the required chemical, without requiring excessive amounts or causing substantial drift outside the target area. Direct exposure of persons can thus be avoided.

Pesticides may leave a residue and concern has been voiced about harmful effects caused by contact with such residues.

Pesticide residue is a controversial subject. Tests have indicated that the insecticides used in Manitoba for adulticiding have no appreciable residual effect on the target secies when dispersed as a fog in accordance with the label instructions. Caged mosquitoes were shown not to be harmed by residual insecticide, being exposed to it one hour after the fogging operation. Therefore, mosquitoes must be actually hit by an insecticide droplet to be killed.

This does not mean that the insecticide does not persist in the environment for an appreciable length of time after fogging. Traces of Baygon have been shown to persist on diverse surfaces for a month or more after aerial application. Repeated adulticiding could conceivably cause a residue buildup that might be cause for concern.

A number of considerations should be kept in mind, though. Firstly, the persistence of propoxur, Malathion and Methoxychlor is very much a function of the existing conditions. The degradation process in a natural environment is bound to be extremely uneven and one should not conclude from the identification of residue traces that the total amount that persist is significant.

Secondly, even if pesticide residue is present on vegetation, on the soil or on other surfaces, it is highly unlikely that persons, frequenting an area for limited periods of time, would pick up significant amounts of pesticide.

Thirdly, insects are much more sensitive to the insecticide than humans and are in much closer contact with vegetation and other surfaces that may be contaminated with the residue. It is logical that any residue of acute toxic hazard to visitors of an area would also have a residual killing effect on insects - which is not the case.

The question of long-term low level exposure should be examined. This is undoubtedly the kind of risk which is foremost in the minds of people objecting to the use of chemical insecticides. In this connection, it must be pointed out that tests have not revealed any carcinogenic, mutagenic or teratogenic effects of propoxur, Malathion or Methoxychlor. Carcinogenic effects have been associated with nitrosated propoxur. But the possible exposure routes mentioned for nitrosopropoxur are: ingestion of contaminated food, leading to possible formation of nitrosopropoxur in the stomach; absorption of propoxur through the skin or by inhalation followed by exposure to $NO_2$ polluted air (diesel exhaust or cigarette smoke); absorption of nitrosopropoxur, that has formed in $NO_2$ polluted air, through the skin or through inhalation of dust particles on which the nitrosopropoxur has been bound. Whether or not these exposure routes are realistic, is a matter of considerable controversy. Even if they are, it is difficult to see how propoxur residue, adhering to vegetation and other surfaces in parks and recreational grounds, could contribute significantly to the exposure to the carcinogen.

It is realized that at this stage no one can rule out the possibility that some nitrosopropoxur may be created after fogging with propoxur in parks and recreational grounds. Neither can one rule out the possibility of human exposure to the substance, once it is formed. On the basis of the available evidence, however, it seems to be a remote possibility.

With residential fogging, the situation is different. In the first place, unlike in parks and recreational grounds, people are exposed. The success of an adulticiding program is dependent on the pervasiveness of the pesticide in the atmosphere. People outside, in cars, or in dwellings, all are directly exposed to a greater or lesser degree. And, whatever residues there are, or whatever compounds are formed, they are found in the areas where people live and where their children play. People can avoid parks that have been sprayed; they cannot avoid exposure in residential areas.

If an entire population is repeatedly and directly exposed to a chemical insecticide, the concept of safety takes on a different complexion. Public health is concerned with individuals and not only with percentages. The question is now whether the available evidence shows it to be unlikely that individuals in the population may suffer harmful effects from the exposure.

Unfortunately, the federal review and test procedures cannot adequately address this question. The response to chemical exposure is not only dependent on species and dosage, it is also dependent on the individual, who may show a greater or a lesser degree of sensitivity to a product. In animal tests, this variability is reduced as much as possible by breeding and selecting the test animals for uniformity. This is entirely correct and necessary to achieve reproducibility of the results. But it should be recognized that the human population, which is exposed, runs the entire spectrum of age as well as that of physical condition.

Furthermore, a relatively infrequent increase in morbidity, say an increase of only a fraction of a percent, may not show up in a comparison of 50 test animals within a control group. This is not a criticism of the federal review and test procedures, which of necessity must deal with the response of populations or of identifiable groups within a population to a given product, rather than with individual responses. While it may be granted that the procedures do not exclude the possibility of relatively rare adverse effects in individuals, it should not not be concluded that such effects are likely to occur.

The Commission has not been made aware of any substantiated clinical evidence of ill-effects following the dispersal of Malathion, Methoxychlor or propoxur in connection with adulticiding operations when used under conditions prescribed in Canada. While this is encouraging, one should realize that symptoms of chemically induced morbidity following fogging, may well escape detection if relatively few individuals in a general population were affected.

It may be concluded that the federal review and test procedures, as well as the available clinical evidence, are consistent with a high degree of safety of the three products mentioned for the population as a whole. They do not answer the question whether or not individuals in the population may be harmed by the exposure associated with repeated residential fogging.

Special attention must be directed towards the possible formation of nitrosopropoxur with residential fogging programs using propoxur (Baygon). The presently available evidence shows that the potential for the formation of nitrosopropoxur in the urban environment exists. Possible exposure routes that may well be found in this environment have also been identified. What is missing, however, is experimental evidence that there is a continuous chain, linking the dispersal of propoxur (Baygon) to the occurrence of cancer in test animals. Some scientists consider the existence of this chain extremely unlikely in view of the instability of nitrosopropoxur under a number of conditions. Others disagree. Under these circumstances, the matter is an additional cause for concern with regard to individual safety in a program causing repeated and widespread exposure to the insecticide.

## 3-4. Conclusions

The public controversy about the control of nuisance mosquitoes has four interrelated focal points:

(1) the severity of the problem;

(2) the effectiveness of the control;

(3) the safety of chemical insecticides used in the programs; and

(4) the rights of individuals in municipal mosquito control programs.

Ongoing nuisance mosquito control programs should not be justified as means of preventing major health problems. It is true that mosquitoes can be carriers of serious diseases such as western equine encephalitis. Nuisance mosquito control programs are not designed for disease control purposes, which requires an entirely different approach, as will be discussed in the next section.

The nuisance caused by mosquitoes varies greatly with time and location. People also respond differently depending on sensitivity, temperament and degree of exposure. In many locations, however, a large segment of the population considers the periodic outbreaks to be a serious source of discomfort and frustration, which, to a considerable degree, interferes with their enjoyment of outdoor activities. This in itself makes the establishment of safe and effective mosquito control programs highly desirable. Unfortunately, both safety and effectiveness are relative concepts when dealing with mosquito control programs.

Concerning effectiveness, it must be conceded that even the best program will not eliminate the nuisance altogether, or prevent it reaching a level many people consider to be intolerable, on occasion.

With regard to safety, there is no doubt that the insecticides used are considered safe when label instructions are followed. But if a large population is repeatedly exposed to an insecticide, all risk of ill effects on susceptible individuals cannot be excluded. This then raises the question to what extent the community has the right to expose an individual to the insecticide against his or her will.

Under these circumstances, it is important that the public is aware of the limitations of nuisance mosquito control programs so that public pressure does not unduly interfere with a balanced judgement of what programs serve the public interest best.

Reducing breeding habitat is a safe, effective and permanent means of reducing mosquito numbers, however, the landscaping effort needed to have a substantial impact would be very extensive and costly. Serious consideration should be given to a public policy of combining the objective of reducing mosquito breeding habitat with all public works that may affect the formation or the drainage of standing pools of water. With respect to private property, public education as well as general sanitation control would asisst in the elimination of incidental mosquito breeding places in the form of containers, old tires, poorly drained property, etc.

A properly conducted larviciding program is the most efficient way of reducing mosquito numbers. It is environmentally acceptable and minimizes human exposure to insecticide. It can usually be conducted without exposing anyone against his or her will to the chemical. For these reasons, it should be the foundation upon which any integrated mosquito control program is built.

In order to be effective, larviciding must be extended far enough beyond the boundaries of the area to be protected to prevent rapid infiltration from adjacent untreated breeding habitat. In addition, depending on the location, summer rains may require repeated larviciding to cope with outbreaks of the summer breeding mosquitoes. Proper timing as well as the judicious selection of the most suitable larvicide is essential for the success of the operation. An effective program thus requires sufficient manpower and equipment as well as a considerable degree of expertise to properly implement the program.

Most municipalities are not in a position to judge what is needed for their particular circumstances and lack the expertise to work out the details of a program. It is essential, therefore, that adequate technical assistance be made available to the municipalities by the Government of Manitoba.

Regarding the safety of the programs, consideration should be given to the use of the biological insecticide BTI as soon as this becomes available especially for areas which may overflow into creeks and rivers, for waters that are used by livestock, or in areas where the proximity of beehives or other features makes the application of the chemical insecticides undesirable.

Adulticiding in parks and recreational grounds can provide effective relief from mosquitoes. Access is generally adequate to permit the fog to penetrate the vegetation effectively so that under the right weather conditions the mosquito population can be decimated. It is true that mosquitoes can and will reinvade the area but fogging can be carried out repeatedly without directly exposing people to the insecticide. The type of insecticide and its rate of application should be such that there is very little residue and whatever residue there is will gradually break down and disappear since the insecticides used are not persistent in the environment. It is extremely unlikely that visitors would be exposed significantly to insecticide residue or to any harmful break-down products or compounds that may form. Moreover, no one is obliged to use the facilities, should he or she be concerned about the presence of insecticide residue or breakdown products. Since the enjoyment of being outdoors or of participation in outdoor activities is the sole reason for having the parks and recreational grounds, the Commission considers an adulticiding operation appropriate if and when mosquito numbers seriously interfere with that enjoyment.

The Commission has reached no conclusions regarding the choice of insecticide. Malathion seems to be the least controversial but cannot be used at relatively low temperatures such as frequently prevail at night during the late Manitoba summer when day temperatures are still high enough to cause mosquitoes to be active. And until the issues surrounding the possible formation of nitrosopropoxur have been clarified, the choice between methoxychlor and propoxur for approved programs is best left with the experts in charge of designing the mosquito control program.

Adulticiding in residential areas is a different matter. In the smaller communities heavily infested areas are often found relatively close to the areas to be protected. Reinvasion of the treated areas is, therefore, rapid. Under these circumstances there may be a tendency to carry out the fogging operation on a regular schedule during the mosquito season. Experience shows that this may be inefficient and ineffective. Mosquito activity will be curtailed at times by wind, temperature or moisture conditions so that the mosquitoes will not be killed by the insecticide. When the fogging is effective, the effect may last from a few hours to one or more days, depending on the rapidity of the reinvasion.

The situation is somewhat different in the larger cities or in other communities where an effective larviciding program has kept mosquito numbers in adjacent areas down. In the City of Winnipeg, it has been found that fogging provides effective relief for one to five days, with an average of somewhat less than three days. Whether or not this degree of relief is considered effective is a matter of opinion.

When residential adulticiding is considered from the viewpoint of safety, a somewhat different picture emerges. While the risk individuals run if repeatedly and directly exposed to the pesticide may be very small, it is neither absent nor imaginary. There is nothing in our society that prevents people from accepting much larger risks in their pursuit of enjoyment or comfort. But subjecting others to risks is a different matter.

Residential fogging exposes people directly to a chemical pesticide in the privacy of their own home and property. Many will welcome this for the sake of a temporary relief from mosquitoes but others object to it and make their objections known. Whether they are right or wrong in their assessment of the risk associated with the fogging may be of secondary importance. Their objections to the fogging of their property are not capricious. These objections should be respected unless by doing so one would violate other rights or cause harm to others.

It would seem, therefore, that, in the first instance, the decision to fog or not to fog residential areas should be made by the elected representatives of the municipality, who presumably reflect the majority views in this regard. But, once the decision to include residential adulticiding in the program is taken, people should be allowed to register their objection to having their property included in the program. Then all reasonable precautions should be taken to prevent the insecticide from getting onto the excluded properties in significant amounts although this will result in a reduction of the effectiveness of the program.

There is ample evidence that fogging operations are a much more effective means of mosquito control when coupled with larviciding in an integrated mosquito control program. An adulticiding program should be under the control of a qualified supervisor, who is able to judge the suitability of the weather conditions as they pertain to both mosquito activity and fog dispersal. The training of such supervisors will require programs sponsored by the Provincial Government.

With regard to the equipment that is being used for adulticiding operations, there appears to be a concensus that the ULV equipment is far superior to the thermal foggers. Because the ULV equipment does not require diesel oil as a carrier and because it makes more efficient use of the insecticide through a better control of droplet size, the thermal foggers should be replaced with ULV equipment, as soon as practical.

There also appears to be a need for the training of the operators of the equipment used both in larviciding and in adulticiding. This is just a matter of operating efficiency. Several persons at the hearing expressed the opinion that the greatest hazard associated with the use of pesticides is the improper handling of the chemicals.

# SECTION 4

# WESTERN EQUINE ENCEPHALITIS

## 4-1. Introduction

The Province of Manitoba has earned high praise from epidemiologists and other experts in the field of public health, both in Canada and abroad, for its program of curbing outbreaks of western equine encephalitis. But in the news media, the program has been severely criticized because of the large-scale aerial spraying with Baygon, carried out in 1975, 1977, and in 1981, when health emergencies had been declared. The actions were referred to as the "Baygon emergencies" that had been created by the program. This resulted in both public concern and public confusion.

Controversy about the prevention program cannot be avoided. The issue is highly complex and evidence concerning the program is, to a degree, incomplete and circumstantial. Moreover, value judgements and risk assessments played a large role in the decisions that were taken. In a concrete situation, decisions must be reached even if the evidence is incomplete and even if there is disagreement. When a decision involves unknowns, uncertainties, risk assessments, benefits, and value judgements, then one can demand only that the decision be made by responsible and knowledgeable persons, and be based on the best available evidence. That criterion must be the focal point of this investigation.

This report will, therefore, not attempt to answer the question whether the 1975, 1977, and 1981 decisions to spray were right or wrong. Neither will it set forth rules to be followed on future occasions. The issue is a public health issue, first and foremost. Public health decisions must remain the responsibility of those officials that hold a statutory responsibility in this field. The investigation must, therefore, concentrate on the decision making process, rather than on the decisions that were reached in 1975, 1977, and 1981.

Some of the questions that should be asked are the following:

- Is, in general, the program supported by the facts known about western equine encephalitis?
- Are the decisions it leads to based on the best available evidence concerning the risk of an impending epidemic?
- Does the program fairly recognize the interests of all who may be affected by it?
- Does it subject persons to risks that are out of proportion to the benefits one may reasonably expect from it?
- Is the program capable of being carried out with efficiency and dispatch?

To answer these questions, the known facts surrounding the western western equine encephalitis program in Manitoba are examined.

## 4-2 The Arbovirus Problem in Manitoba

### 4-2-1 The Disease

Western equine encephalitis (W.E.E.) is one of several arbovirus infections that affect the central nervous system in humans and may cause irreversible damage. The disease is commonly referred to as "sleeping sickness".

The virus that causes W.E.E. is the Western Encephalitis (WE) virus. Other important arboviruses that may cause sleeping sickness are: Eastern Encephalitis (EE) virus, Saint Louis Encephalitis (SLE) virus and California Encephalitis (CE) virus. EE has been identified in showshoe hares in Alberta and SLE and various strains of CE have occasionally been found by serological procedures. To date they have not been shown to be significant in outbreaks of encephalitis in Western Canada; however, they may, become a more serious problem in the future.

The arboviruses are transmitted mainly by mosquitoes. But mosquito species differ very much in importance as vectors for a particular arbovirus. WE virus is primarily transmitted by the Culex tarsalis mosquito, which at times is quite abundant in Manitoba. Other mosquito species have been shown to become infected with WE virus but do not appear to play an important role in the virus transmission to man.

Most people that have been infected do not show any sign of it and overcome the infection without any apparent ill-effects. These are commonly referred to as subclinical cases. Others may show flu-like symptoms, such as: headaches, fever, chills, nausea and vomiting, which are the early manifestations of the disease. It is impossible to estimate how many persons fall in this category, since the symptoms may well be ascribed to influenza and many recover without further signs of the disease.

Early symptoms indicative of the involvement of the central nervous system are: mental confusion, tiredness and a pronounced sleepiness. As the disease advances sleepiness may be replaced by coma and eventually by death. The inflammation or irritation of the brain and spinal cord tissues may give rise, at some stage of the disease, to a variety of symptoms, such as a stiff neck, tremors, spastic muscles, paralysis and a high fever. As the inflammation proceeds, brain cells may suffer irreversible damage, leading to permanent disabilities, developmental and mental retardation, personality changes, insomnia and hyperactivity. Permanent aftereffects are uncommon, except in small children. Mortality rates vary considerably from epidemic to epidemic. An average figure of 10% has been quoted.

There is no specific therapy for the disease. Treatment is symptomatic and aimed at strengthening the patient's ability to overcome the infection.

Western equine encephalitis occurs in all age groups but mostly in the very young and in persons over the age of 50 years. Mortality and permanent aftereffects occur most frequently in infants.

Western equine encephalitis is thus a very serious disease. Fortunately, it is relatively rare.

The history of W.E.E. outbreaks in Manitoba is obscured by the fact that only in recent years positive identification of the disease has become possible through serological testing in the public health laboratory.

WE virus was first recognized as the cause of sleeping sickness in horses in 1930 when the virus was isolated in California. That is why the disease was called western equine encephalitis. In 1932, the disease was first recognized in Manitoba among horses. Throughout the 30's, human infections were suspected but no positive diagnosis was possible at that time. The history of western equine encephalitis epidemics in Manitoba thus starts with the major outbreak in 1941.

A particularly heavy infestation of mosquitoes, in July 1941, was followed by a W.E.E. epidemic that lasted three to four weeks and numbered 509 cases. Seventy-eight people died. Of those who survived, many suffered major and long lasting aftereffects, especially the very young children. In 1947, another outbreak occurred in which there were 81 cases but no deaths. From 1947 to 1975, the disease occurred sporadically in Manitoba. No precise numbers are available for the early part of this period. In the late 50's, however, serological testing for W.E.E. began on a routine basis in the Manitoba Provincial Public Health Laboratory. The laboratory confirmed two cases in 1960, one in 1961, one in 1969, and one in 1972. Adding to this, the so-called presumptive cases, in which tests were either inconclusive or not done, brings the total for the period 1960 to 1975 to 15 cases.

In 1975, there were 14 cases, of whom six were hospitalized for more than two weeks. Of the 14, eight recovered quickly without any aftereffects. In two patients, aftereffects lasted a few months but then disappeared. Four patients suffered more or less permanent damage. A 62 year old man was left with a weakness of one arm; a 38 year old woman suffered a personality change with an evident loss of intellect and mental ability; an 8 week old infant suffered retardation of development and a 7 week old infant is now a mentally retarded spastic quadriplegic. No deaths were recorded.

In 1977, five cases of W.E.E. were confirmed and in 1981, 25 cases. Thus there were 44 confirmed cases in the period 1975 to 1981. One may add to this 24 presumptive cases in which the laboratory tests were inconclusive.

Of the 25 cases recorded in 1981, 18 were hospitalized for periods ranging from 3 days to 4 months and an average of 9 days. Two patients died. Patients interviewed two to three months later reported problems with being tired, irritability, loss of fine finger control and memory lapses. It is not possible at the present time to assess fully the aftereffects of the 1981 epidemic. Only one child less than one year old was affected by the disease and it made a complete recovery.

It should be noted that aerial spraying in the epidemic years of 1975, 1977 and 1981 may have modified the course of the epidemic in those years and reduced the number of cases.

### 4-2-2 The Western Equine Encephalitis Cycle

The name western equine encephalitis, W.E.E., is somewhat misleading because the disease also affects humans and birds. Small rodents and reptiles may also be affected or may be carriers of the virus. Of the mammals, only horses and people are susceptible. Other mammals may become infected but do not appear to suffer any ill-effects. The virus persists for only a very short time in the blood stream of man or horse. Both are, therefore, called dead-end hosts that play no part in the transmission of the virus.

The origin of the virus is only partially known. It seems that the virus cycle is largely localized. During the winter, a virus reservoir is maintained, perhaps in birds, reptiles or hibernating rodents. Migratory birds may bring virus into the Province in the spring, but there are no indications that they play an important role in the annual cycle of the virus.

It is possible that, during the spring and early summer, an amplification of the virus reservoir occurs when juvenile and nestling birds are bitten by infected mosquitoes. The presence of the virus is clearly demonstrated in the sentinel chicken flocks that, under the arbovirus surveillance program, are exposed to the mosquitoes and tested regularly to determine the level of antibodies in their blood. The percentage of infected chickens thus shows each year the presence of the virus in the environment. In nonepidemic years the percentage usually remains below 20%. In epidemic years it may reach 100%.

The primary mosquito vector of WE virus is the Culex tarsalis which is a bird feeding mosquito. Large numbers of Culex tarsalis often means large numbers of infected birds. But Culex tarsalis also bites humans and horses. The combination of large numbers of infected birds and large numbers of Culex tarsalis is, therefore, a good indicator of an impending epidemic.

Another indicator of an impending epidemic is the incidence of W.E.E. among horses. The disease is very severe in horses. A large percentage of the infected horses show clinical signs; long-term effects are serious and mortality is 20% to 25%. Fortunately, a vaccine has been developed that provides protection to horses, if inoculated on an annual basis.

The incidence of W.E.E. in horses usually follows the incidence of chicken flock infections by one to two weeks. Human cases appear two to three weeks later if an epidemic does occur. This sequence reflects the preference of the Culex tarsalis, the greater exposure of horses compared to people and the length of the incubation period which is a little shorter for horses than for humans.

Horses are not always a good indicator of the danger of an epidemic. In 1941, the disease was not particularly prevalent among horses and 509 human cases were reported in that year.

On the whole, however, the virus cycle presents a consistent and annually recurring picture in which only the numbers vary from year to year. This offers the opportunity of making a reasonably reliable assessment of the risk of a W.E.E. epidemic in time to take preventive action.

Three factors must be present for a W.E.E. epidemic to occur. The virus must be abundant near human populations; the vector transmitting the virus, the Culex tarsalis, must be present in sufficiently large numbers; and there must be sufficient exposure of a susceptible population.

The virus level in various locations of the Province can be assessed reliably by means of sentinel chicken flocks. Experience shows that infection levels in these chickens must exceed 20% before there is a substantial danger of an epidemic. An infection rate of 30% coupled with the occurrence of 6 or more horse cases per week has been adopted in Manitoba as sufficient evidence of an impending epidemic to take emergency measures.

But infections of chickens and horses may occur quite rapidly and may reflect fairly advanced stages in a virus amplification process that has begun much earlier. It would be highly desirable if other indicators of high virus levels could be found so that earlier warning of increased risk could be obtained. This requires further research into the virus cycle and into the factors that govern the persistence, the transmission and the amplification of the virus in the environment.

Concerning the second factor, Culex tarsalis is a mosquito species that comes fairly late out of hibernation, around the middle of June. It is a summer breeding mosquito and if temperatures are above normal several generations of mosquitoes may be produced in the remaining summer months. Adult females begin to go into hibernation in late August and early September. They do this without taking a blood meal first. Thus the last generation of Culex tarsalis in the summer will not bite people or horses and plays no role in any epidemic of that year. Unseasonably warm weather may delay hibernation and this may make it difficult to decide whether or not an emergence of Culex tarsalis towards the end of August necessitates a spraying operation.

Culex tarsalis prefers to breed in small artificial or natural containers where it lays its eggs in rafts. Rainfall, humidity and high temperatures increase both the numbers and the activity of the mosquitoes and are important parameters in the WE cycle. The relative abundance of Culex tarsalis can be determined by a variety of mosquito traps. Daily surveys are needed during the summer to provide an early assessment of the danger of a W.E.E. outbreak.

The third major factor in the occurrence and severity of an epidemic is the exposure of a susceptible population.

It is perhaps surprising that not more people are not infected with W.E.E. Even in nonepidemic years, the WE virus is present in sufficient quantity to infect up to 20% of the sentinel chicken flocks. And Culex tarsalis is a rather common mosquito in Manitoba, comprising between one and ten percent of the adult mosquito population.

It appears that many people may become infected and develop antibodies without showing any symptoms of the disease. The ratio of apparent to nonapparent cases has been estimated as high as 1:1000, and there is considerable uncertainty about the number of people that have acquired antibodies in subclinical infections. A limited amount of testing in Manitoba indicated antibodies in only 5% of the population (1982 Date - 9%). Much higher figures, over 60%, have been obtained in local areas in Saskatchewan. It is also not known how long antibodies will remain in the human body. Thus there are many unanswered questions about the susceptibility of the human population to W.E.E. There is a need for a well stratified serosurvey for WEE, SLE, CE, with adequate numbers for each age group, each sex and each region in Manitoba.

Reducing the degree of exposure by protective clothing, repellents, avoiding mosquito infested areas, and timing protective measures with times of highest mosquito activity, will reduce the risk of contracting W.E.E. It was claimed by several speakers at the public hearings that individuals can virtually eliminate the risk in this manner; however, reducing the degree of exposure of a population by such measures is difficult to achieve.

## 4-3 The Manitoba Western Equine Encephalitis Prevention Program

### 4-3-1 General

The Manitoba W.E.E. Prevention Program has its origin in a 1974 review of procedures that should be followed in the event of a public health emergency in the Province, such as a major accident, a flood or an epidemic. The Department of Health and Social Development initiated discussions since it was perceived that normal procedures might not adequately cope with such situations. Spraying of residential and recreational areas with insecticide at that time required an order of The Clean Environment Commission. Preparing such an order could involve public hearings and appeal procedures. This process could have eliminated a spraying program as a means of dealing with an insect-borne epidemic.

The development of emergency procedures for dealing with W.E.E. was greatly accelerated in 1975 by the epidemic which occurred at that time. With minor modifications, the program then established is still in force. It came into full-fledged action in 1975, in 1977, and in 1981.

The prevention program consists of three major components:

a) a monitoring program undertaken by the Manitoba Arbovirus Surveillance Committee;

b) a decision making process, which decides on emergency action;

c) an emergency measures program, dealing with the steps taken in the event of a declared health emergency.

These three components will be discussed briefly in this chapter.

### 4-3-2 The Monitoring Program

The Manitoba Arbovirus Surveillance Committee is a permanent committee of professionals in a variety of disciplines. Its task is to assess and report on the risk of an outbreak of W.E.E. Specifically, the Committee monitors:

a) weather conditions as they relate to the relative abundance of the disease vectors;

b) mosquito trap data for time and aerial distribution of Culex tarsalis;

c) evidence of the presence of W.E.E virus in the mosquitoes caught;

d) the incidence of W.E.E infection in a number of sentinel chicken flocks;

e) the incidence of horse cases of W.E.E. in the province;

f) the incidence of human cases in the province and in neighboring jurisdictions.

Mosquito traps give the first indication of danger. Three different kinds of traps are being used. In live-mosquito traps, the mosquitoes are attracted by light and drawn into a collecting cage by means of a motor-driven fan. There they remain alive until the traps are emptied, which is done three times a week. The mosquitoes are separated by species, counted, and sent to the Public Health Laboratory where they are ground up and analysed for virus.

The City of Winnipeg operates a number of New Jersey light traps in which the mosquitoes are killed by an insecticide after being caught. At the present time, there are 15 such traps inside the City and 4 outside for comparison.

A third type of trap is the flock trap, which is attached to the sentinel chicken flock cages. Mosquitoes are attracted by the live birds in the cage, and enter the trap, where they are caught alive. These mosquitoes can also be used for virus indentification.

The flock traps are very useful in that they attract mainly the bird feeding mosquitoes of which Culex tarsalis is one. In addition, the flock trap does not attract female Culex tarsalis that are about to go into hibernation and that, therefore, are not looking for a blood meal. Thus they more accurately reflect the number of problem mosquitoes.

Mosquito numbers caught in traps have been shown to be very useful as indicators of the danger of W.E.E. The numbers of Culex tarsalis caught in the epidemic years were very much in excess of those caught in non-epidemic years. The incidence of virus infection also proved to be of great predictive value.

The relative abundance of Culex tarsalis varies from location to location and so does the danger of W.E.E. Monitoring must be performed at a sufficient number of locations and mustbe continuous to provide a suitable basis for comparison. It is, therefore, a matter of concern that during the nonepidemic years following 1975 the number of surveillance points and sentinel chicken flocks has been reduced because of cost.

In 1975, a total of 15 sentinel flocks were installed at various locations in the Province. This number was gradually reduced until in 1981 only five flocks were in place. The rationale of these reductions must be questioned in the light of the very large amounts of money that are being spent in epidemic years to conduct emergency operations.

Originally all the chickens were bled and replaced with new chickens every two weeks. The serum is checked in the laboratory for antibodies (seroconversion). In 1981, a somewhat different procedure was followed in that only those birds that had developed antibodies were removed. This procedure avoids removal of birds that may have become infected but that have not yet formed sufficient antibodies to demonstrate the required degree of seroconversion. Bleeding intervals were reduced in 1981 from two weeks to one week. The sentinel chicken flock operation has thus become more sensitive to changes in the presence of virus in the environment.

Seroconversion in chicken flocks has been shown to be a very important parameter in the surveillance program. It can be stated that a comparison of epidemic and nonepidemic years has shown that a 20% seroconversion is a useful early warning signal, while a 30% seroconversion is a definite danger signal.

The surveillance of horse cases is important since horse cases precede human cases usually by two to three weeks. A rate of 6 horse cases per week has been adopted as a criterion for an epizootic of W.E.E. among horses. This has also been accepted as a danger signal for a W.E.E. epidemic.

As an example of the significance of the surveillance program, the following sequence of events may be quoted for the year 1981:

- First week in July. The mean number of Culex tarsalis in flock traps increases rapidly at a rate approximately ten times the rate in nonepidemic years.

- Second week in July. Continuing increase in Culex tarsalis. Virus isolation from trapped mosquitoes reaches significant levels.

- Third week in July. Seroconversion of chicken flocks in excess of 20%. Light traps show a significant increase in Culex tarsalis. Flock trap counts remain steady but high.

- Fourth week in July. Culex tarsalis reaches a peak. First equine case confirmed.

- End of July. Emergency declared.

The first human case was diagnosed on August 13 but had contracted the infection presumably in the early part of July. Further human cases occurred from late July on throughout the month of August.

The sequence shows the great importance of the flock traps and the virus isolation from the mosquitoes in making an early prediction possible. Light traps reacted about two weeks later.

### 4-3-3 The Decision Making Process

Once the Arbovirus Surveillance Committee has determined that there is a danger of a W.E.E. outbreak, it reports directly to the Minister of Health. The Minister then informs the Emergency Measures Organization (EMO) which has the responsibility of responding to emergency situations. EMO then alerts other Departments and agencies that may become involved and in co-operation with them establishes an Emergency Measures Task Force Committee that will deal with the situation under chairmanship of the Co-ordinator of EMO.

At the same time ,an ad hoc committee of Cabinet is formed by the Ministers of the Departments involved, such as the Minister of Health, Agriculture, Environment, the Attorney-General, etc. This subcommittee represents the political arm of Government in the decision making process. A committee of deputy ministers is also formed to co-ordinate the work required by the various departments.

The Emergency Measures Task Force Committee has a three-fold task. First, it must review the situation in the light of the information that will become available, for example, from the continuing work of the Arbovirus Surveillance Committee. Secondly, it must provide the Committee of Cabinet with advice on the emergency measures that are needed. Thirdly, it must direct the operations that are aimed at coping with the emergency.

All formal decisions are made by the Committee of Cabinet, such as the declaration of an emergency, the decision to spray and where or when to spray, the decision to allocate funds, etc. In practise, however, the political arm, the administrative arm and the task force act as a unit.

The Emergency Measures Task Force Committee is an operational committee. Its members are chosen on the basis of the role they can play in rendering advice to the Government or in steering or directing the emergency measures themselves.

Once the Emergency Measures Task Force Committee is in operation, it establishes an information centre and an on-site team that is responsible for the aerial spraying program, if necessary. The organization is quite flexible and can deal with the situation as it develops effectively and efficiently.

The strength of the organizational structure that has been chosen lies undoubtedly in its ability to bring all aspects of the decision making process together as one group: information, expert assessment of the incoming data, political decision, special interests, mobilization of manpower and equipment, funding, and technical execution of the emergency measures program. It would be difficult to improve upon this procedure.

### 4-3-4 The Emergency Program

There are presently only two ways of reducing the impact of a W.E.E. epidemic. One is by killing the disease vector, the Culex tarsalis, and the other is by increasing public awareness of the need for personal protection against mosquito bites. Both are components of the emergency program.

The only practical way of destroying large numbers of Culex tarsalis is by large-scale aerial spraying. Ground fogging operations may be carried out simultaneously but are unlikely to have a substantial impact because of the limited area that can be covered in time. Spraying with a large aircraft can kill mosquitoes over a large area which reduces the danger of reinfestation. Moreover, it can be done in a relatively short time which can be made to coincide as much as possible with the time the mosquitoes are actively flying.

The insecticide Baygon has been used in the past in a special formulation intended for aerial spraying with ULV equipment. The rate of application used was 52.5 grams active ingredient per hectare.

A number of problems have occurred in the past and will likely occur again in the future. One problem is making people aware of the intention to spray a given area.

In spite of considerable effort on the part of the Emergency Measures Task Force Committee, many at the public hearings complained of insufficient warnings. There is no evidence that incidental exposure to the infrequent aerial spraying constitutes a health hazard, but people who so desire should have ample opportunity of avoiding the exposure. Bee keepers also should be fully informed at all times of any intended spraying in their area. This aspect of the emergency program should receive additional consideration.

Another aspect that requires further attention is the monitoring of the program for efficacy and side effects. In a following chapter, the question of safety and efficacy will be reviewed in more detail. It may be noted here that efficacy under operating conditions can only be determined reliably by a properly designed monitoring program. Emergency programs are very costly and warrant considerable effort in determining how effective they are and in what way their effectiveness can be improved.

Environment Canada and the Federal Department of Fisheries undertook monitoring of the spraying in 1981 in order to determine whether there were significant environmental impacts. Their general conclusion was that there were no significant adverse effects on the environment. It was evident that the monitoring program could and should be improved. Concerns remained about the operational effect of the spraying program on bees and about ways in which these effects could be minimized.

The second way of reducing the severity of a W.E.E. epidemic is by motivating people towards increased personal protection against mosquito bites. Concerted attempts have been made to achieve this goal but it is questionable whether the attempts have been successful.

Public health officials have drawn attention to the fact that in the 1981 epidemic only one child under the age of 1 year contracted the disease out of a total number of 25 cases. This was seen as an indication that many mothers took care to protect their infants during the epidemic although the evidence is not overwhelming. In 1941, the percentage of children under one year was about 5%, in 1975 it was 14% and in 1981 it was 4%. Public response is difficult to measure in a case like this.

Personal protection is of great importance for there is no more effective way of curbing an epidemic than if a sufficient level of public awareness can be achieved. There is no intention to suggest that the emergency program failed to give proper attention to this matter. It is suggested, however, that serious study should be given to methods of ensuring that public awareness programs become more effective.

## 4-4 Alternative or Complementary Courses of Action

### 4-4-1 General

A complete assessment of the Manitoba W.E.E. prevention program cannot be made without considering alternative or complementary means of curbing outbreaks of epidemics.

Large-scale aerial spraying operations are not an ideal way of dealing with insect borne epidemics. An aerial spraying eliminates at best a single generation of mosquitoes. If the outbreak occurs relatively early in the summer, then another generation of Culex tarsalis may emerge and become infected, and the spraying must be repeated. Large-scale aerial spraying is expensive. Direct costs of 1 million, 1.5 million and nearly 2 million dollars have been quoted for the 1975, the 1977, and the 1981 operations. In addition, the programs represent a considerable effort in terms of time and expertise. The operation is weather-dependent and does not eliminate the disease.

Theoretically, an epidemic can be prevented or its severity reduced by interrupting the cycle of the virus as it leads up to human incidence of disease. Present knowledge provides only three ways of modifying the course of an epidemic:

1) by killing adult mosquitoes;

2) by protecting people from mosquito bites;

3) by increasing their resistance through immunization.

Immunization will first be reviewed, after which attention will be given to personal protection against mosquito bites.

## 4-4-2 Vaccination Against Western Equine Encephalitis

Major outbreaks of W.E.E. among horses in the 1930's and earlier led to the development of a vaccine that proved to be effective in protecting horses against the disease. Since that time, many horses have been vaccinated annually and the incidence of the disease among horses has been reduced dramatically.

In the early 1960's a vaccine for human use was developed at the Walter Reid Army Institute in Washington. It was intended for use by U.S. Army Corps of Engineers personnel, who happened to be at increased risk, such as field staff in areas where the disease was considered prevalent, and laboratory personnel. There was no intention of using the vaccine for the protection of the civilian population. The vaccine was subsequently modified and improved. Limited quantities of W.E.E. vaccine are being kept on hand by the U.S. Army for its own use.

The vaccine is a suspension of W.E.E. virus grown in chick embryo cell culture and inactivated with formalin. It is not particularly suitable for mass immunization for it requires a course of three doses to be given with an interval of four weeks between doses. In addition a booster dose 7 to 12 months after the third dose is recommended.

The major outbreaks in Saskatchewan of W.E.E. in 1963 and 1965 led to a program of vaccination trials. Connaught Medical Laboratories were requested to manufacture the vaccine and field trials were conducted up to 1975. Attempts were made to obtain a vaccine that would reliably induce antibodies when given as two doses, one week apart, and that would retain its antigenicity if stored for two to five years. Such a vaccine would make a crash immunization program possible for epidemics occurring at irregular intervals.

The results in Saskatachewan were not encouraging. Response to 3 doses vaccination was excellent but response to two doses was spotty. The effective time of immunization, after vaccination, is believed to be short -

possibly only one year. In addition, the vaccine quickly deteriorated with time. In 1975, the program was abandoned partly because eight years had passed in Saskatchewan without a single W.E.E. casuality.

There is little doubt that with adequate funding a suitable vaccine can be developed. The development, however, would be expensive. In addition, mass immunization, either on a routine basis or as a crash program, is a formidable undertaking.

At the present time, it is quite doubtful that commercial development of a vaccine suitable for mass vaccination will be developed in the foreseeable future. Such a vaccine could be developed with suitable financial incentives from the Federal and Provincial Governments. The question whether or not that would be an appropriate allocation of public health funds is not one for the Commission to answer and falls outside the ambit of the present investigation.

A study undertaken by the Department of Public Health in Saskatchewan notes that the most serious consequences of W.E.E. are the permanently disabling aftereffects that occur. But the study also notes that 75% of these effects occur in children who contracted the disease in the first six months of their life. Immunization of this age group would, therefore, eliminate a large portion of the disablement caused by the disease. An immunization program aimed at protecting the very young would not be such a formidable undertaking as mass immunization of an entire population. The requirement of repeated vaccination would be less of an impediment. But vaccination of young infants would have to be supplemented by vaccination of the pregnant women to ensure protection of newborn babies in the period prior to vaccine-induced immunity.

### 4-4-3 Personal Protection Against Western Equine Encephalitis

Mosquito activity in the hour around sunset and around sunrise is about ten times the activity during the rest of the day or night. One can, therefore, substantially reduce the risk of infection by reducing exposure during the peaks of mosquito activity. The risk of infection can also be obtained by wearing suitable clothing, by applying repellents and by avoiding mosquito-infested areas.

Public Health officials at the hearings claimed that by elementary protective measures one could virtually eliminate all risk of becoming infected with WE virus.

It would seem, therefore, that during a declared health emergency, major emphasis should be placed on efforts aimed at motivating people towards personal protection and protection of their children.

It is very unlikely that an entire population could be induced to follow protective practises across the Province for a whole month. Areas of greater than average risk could be identified as the situation develops. A campaign directed towards specific areas and that would gradually expand to other areas of risk would be more dynamic, more personal and probably more effective than admonitions directed at the people at large. It would require a considerable expansion of the sentinel flock program to be able to identify specific areas at risk quickly and reliably.

The protection of infants should be a primary objective.

## 4-5 Assessment

### 4-5-1 General

Concerns expressed at the public hearings focussed on the effectiveness, the safety and the environmental impact of the Manitoba W.E.E. Control Program. These concerns led to numerous suggestions ranging from relatively minor extensions and improvements all the way to suggestions that the program in its present form be abandoned and replaced with other courses of action.

The effectiveness issue is crucial for a program as ambitious, as costly and as controversial as this one. There are many facets to effectiveness and many questions for which definitive answers are not yet available. Nevertheless, the purpose of this investigation is to determine whether or not the program can reasonably be expected to significantly reduce the ill-effects of W.E.E. in this province. That assessment must be made in the light of the best available evidence.

The program must also be assessed in terms of human safety. Some people have the opinion that the cure is worse than the illness. One may disagree with this opinion, but not with their premise that the comparison must be attempted; there must be a reasonable expectation that the public health benefits of the program far outweigh any public health risk. Parallel with this general public health aspect, one must consider special risk categories and the extent to which their interests are protected.

Finally, the environemntal impact on nontarget species must be evaluated as a possible environmental cost of the program. In this assessment, the evidence on the impact of the spraying program on mammals, birds, fish and bees will be reviewed.

### 4-5-2 Effectiveness

There are three levels at which the effectiveness question must be raised. The first level relates to the ability of the program to swing into competent action at the appropriate time. The second level relates to the immediate target: adequately reducing the exposure to infected biting mosquitoes. The third level is concerned with the ultimate goal of the exercise: reducing the incidence of ill effects from W.E.E. in the Province.

Effective action, in whatever form, requires, in the first place, timely and reliable prediction of the risk of W.E.E. The Arbovirus Surveillance Program has done a commendable job in accurately assessing this risk each year since the program was established in 1975.

Evidence presented at the hearings showed beyond question that the sentinel chicken flocks used in the program are uniquely capable of:

a) providing an early indication of the rise in Culex tarsalis numbers usually associated with an outbreak of W.E.E.;

b) providing early indications of the prevalence of WE virus in the mosquitoes;

c) providing a reliable assessment of the probability of an imminent outbreak of W.E.E. based on the percentage seroconversion in the chickens.

While much has been achieved, there is no cause for complacency. The first confirmed human case in 1981 fell ill on July 16. He was presumably infected in the first week of July. At that time, the numbers of Culex tarsalis caught in the flock traps had started to increase rapidly, but neither the virus isolated from the mosquitoes, nor the seroconversions in the flocks had shown serious danger signals. This is not to suggest that aerial spraying in 1981 should have started early enough to prevent this infection. The early warning system serves the purpose of deciding whether and when to set the aerial spraying program into motion. Warning the public of the risk of W.E.E. is also a most important function.

One must in this connection seriously question the wisdom of the reduction of sentinel flock stations from 15 in 1975 to 5 in 1981. This reduction was made for budgetary reasons, not because of a proven redundancy. In fact, the location of the present stations in Charleswood, Brandon, Portage la Prairie, Oak Hammock and Glenlea leaves large areas of the Province that are not covered. Experience shows that increased presence of virus and seroconversion does not occur at the same time in all of the flocks. It was pointed out at the hearings that during the epidemic year 1981 no arbovirus was isolated from the Brandon flock and that seroconversion in this flock did not start till August, more than two weeks after the flocks in Charleswood and Portage. From the viewpoint of issuing public warnings, it would seem essential that enough stations are in operation to allow a differentiation in danger levels according to time and location.

Continuity of stations is of great importance. The signals of an immediately impending epidemic may not be difficult to read, but to use the early data for an assessment of the virus progression and the mosquito amplification requires a careful comparison of the information from year to year. There is, therefore, a need for more stations which should be part of a carefully designed continuing plan.

There are too many unknowns in the virus cycle. There is considerable uncertainty about the role of other mosquito species that have been shown to become infected with WE virus, in particular, the Culiseta inornata, the Culex restuans and, to some extent, the Aedes vexans. Little is known about the WE winter reservoir or about its amplification in the early spring. These are not academic questions, for the proper design of a monitoring system depends on an understanding of the principal features of the virus cycle. The work of the Arbovirus Surveillance Committee should, therefore, be augmented with research efforts aimed at increasing this understanding.

Another aspect of efficiency at the action level concerns the decision making process, the organization for action and its execution. All evidence presented at the hearings confirmed that this aspect leaves very little to be desired. The Manitoba program undoubtedly deserved the high praise it has earned from experts from other jurisdictions. It may also be noted that a spokesman for Environment Canada, reporting on the monitoring done by the federal agencies, said that the operation was carried out very professionally and competently.

Some criticism was leveled at the program for its failure to keep the public fully informed of the areas where and the times during which spraying was to take place. A certain amount of misunderstanding on the part of the general public is probably inevitable. The Provincial Apiarist of the Manitoba Department of Agriculture reported at the hearings on attempts to monitor the effect of the 1981 aerial spraying on honeybees by a series of field observations. He said that most attempts were hampered by the unpredictability of the spray program. He also stated that attempts by beekeepers to protect their bees were made much more difficult, if not impossible, by the lack of adequate forewarning of most of the Baygon applications. Other evidence showed clearly that serious attempts were made to keep the public informed of the program and of the inevitable changes necessitated by the vagaries of the weather. Therefore, this is a matter that requires further attention.

When effectiveness is considered in relation to the reduction of exposure to infected biting mosquitoes, two areas of investigation arise. One is the effectiveness of the aerial spraying program, the other, the effectiveness of efforts aimed at promoting personal protection.

The aerial spraying programs in 1975, 1977, and 1981 undoubtedly killed large numbers of mosquitoes. This is borne out by a limited number of tests performed in these epidemic years on caged mosquitoes that were placed in the spray areas under a variety of exposure conditions. In addition, Dr. R. Brust, Professor of Entomology at the University of Manitoba, conducted bite count experiments at two sites in the Winnipeg area prior to and after the aerial spraying in 1981.

The experiments confirmed that very high mosquito mortality figures can be expected when the spraying is conducted at times when the mosquitoes are actively flying. Under such conditions, the exposure of the mosquitoes to the insecticide is at least equal to and probably greater than the exposure of caged mosquitoes in open areas for which an average mortality of 87% was observed in nine tests during the three epidemic years.

Shelter decreases mosquito mortality. In 1975 and 1977, tests were also performed with cages that were placed at ground level in tall grass. These showed average mortality figures of 49%. Similar tests with cages under trees gave mortality figures averaging 42%.

The very high mortality of exposed mosquitoes was also confirmed by the bite count experiments conducted by Dr. Brust. Warm nights preceding the spraying operations resulted in relatively high bite counts in spite of previous ground fogging operations in the City of Winnipeg. But while the warm weather continued, the bite counts in two nights after the spraying dropped to about 10% of what they had been. Then the bite counts gradually increased and they reached prespray levels on the fifth night following the spray operation.

No bite counts experiments were performed in 1975 and 1977. They would not have been meaningful because cool weather set in during and immediately after the spraying. This in itself significantly reduced the mosquito activity and the risk of infections with W.E.E.

This experimental evidence is, in itself, not conclusive. But it confirms what one would expect on the basis of general knowledge of adulticiding operations and it strongly supports the contention that aerial spraying can literally decimate a mosquito population if the conditions and the timing are right. But when conditions are such that mosquitoes remain in the shelter of vegetation the mortality is probably cut in half.

Spraying efficiency is also dependent on the even distribution of the insecticide by the aircraft. Some concern has been experessed in this regard in connection with two different types of experiments: the measurement of the percentage of Baygon that actually reached the ground, and the observations of the mortality of caged bees placed in the spray area.

Measurement of spray deposit was conducted in 1975 and in 1981. Teflon coated plates were placed at ground level in a number of locations that were to be sprayed. The drop deposits were then determined. Because of dispersion and volatization of the very fine droplets one would expect that only a fraction of the insecticide released by the aircraft would reach the ground. This was generally confirmed, but the percentages showed a rather wide variation and a major anomaly.

On August 18, 1975, the average deposit at eight locations spread throughout the Winnipeg area was 177% of the amount released from the aircraft. This is difficult to explain. Disregarding this anomaly, the average percentages at other times and locations varied from a low of 0.7% to a high of 7.5% in 1975. In 1981, the percentages varied from a low of 2.8% to a high of 18.2%.

It is not at all clear what any specific percentage means in terms of killing mosquitoes. But the variation may indicate a variability in effectiveness due to uneven distribution of the insecticide.

During the 1981 emergency, the apiculture staff of the Manitoba Department of Agriculture placed sets of 4 to 121 cages with live bees in six different locations in the Province. Several control cages were also placed in the same general locations but outside the sprayed area. The mortality in the cages varied from zero to 100%. Although the average mortality in the six locations varied from zero to 52%; further investigation to evaluate spraying efficency appears warranted.

Effectiveness in killing mosquitoes should not be equated with effectiveness in reducing exposure to W.E.E. In 1981, the optimum conditions for spraying existed. The weather stayed warm and the aerial spraying operation substantially reduced the large Culex tarsalis population. In 1975, the weather turned cool right after the spraying and, in 1977, the number of biting Culex tarsalis had already started a rapid decline when the spraying began. This does not mean that the decision to spray in 1975 and in 1977 was wrong. One cannot predict weather conditions sufficiently to forecast mosquito behaviour several days in advance. It is, therefore, unavoidable that in retrospect the usefulness of an aerial spraying operation may be open to question.

Five days after the spraying Culex tarsalis mosquitoes were back to prespray levels according to Dr. Brust's bite count experiment. Experience elsewhere in 1981 also showed a relatively rapid reinfestation. While some of these mosquitoes may have migrated in from unsprayed areas, it appeared that there were new Culex tarsalis coming out well into September. It is not likely that these posed a substantial danger since they may have been about to go into hibernation and because they may not have been infected to the same degree.

The Commission did not hear a great deal of evidence about the promotion of personal protection or the effectiveness of the promotion that was carried out. However, the Commission considers a public information program, promoting personal protection, to be an important part of the total prevention program.

Finally, the program must be assessed in the light of the overall objective: reducing the incidence of ill effects from W.E.E. in Manitoba.

Serious questions about the overall effectiveness were raised at the public hearings by Dr. A. Ronald, an infectious disease internist, who has personally attended about a third of the clinically ill patients during the last three epidemics. Dr. Ronald made the statement that there is no sound evidence that spraying operations can modify the course of a W.E.E. epidemic. He based his own scepticism on the distribution of urban and rural cases during the course of an epidemic. The spraying program, being directed primarily at the urban population, should result in a reduction of the W.E.E. incidence in urban areas while the rural incidence would not be affected to the same degree. Dr. Ronald believed that there was no evidence of such a trend.

Indeed, Dr. Ronald felt that, if anything, the spraying program was countereffective. It conveyed the impression that the major strategy was the large-scale aerial spraying operation, whereas the major strategy should have been increased personal protection.

In assessing this criticism, it must be granted that the overall effectiveness of the program is not proven but inferred. The argument is, reducing the number of infected mosquitoes reduces the probability that a person may be infected, thereby reducing the probability of the occurrence of major ill effects. This is straightforward reasoning. Furthermore, the disease is too infrequent and the number of cases too few to show clearly any differences in the course of an epidemic between rural and urban areas. That does not mean that Dr. Ronald is wrong, it means that, at the present time, the overall effectiveness of the spraying operations cannot be decided on the basis of the available epidemiological data.

Dr. Ronald's other point, that the emphasis should be on increased personal protection, can be readily conceded provided means can be found to raise public awareness and public interest sufficiently to make this a success.

### 4-5-3 Safety

The emergency spraying operation naturally prompts the question: Is there not a safer insecticide than Baygon that could be used? The answer is: No. The only other insecticide that is registered in Canada for ULV aerial application against biting flies is Malathion. Malathion cannot be used because it has a reduced effectiveness at temperatures below 15°Celsius. Such temperatures are not uncommon in Manitoba evenings during the months of August.

The major concern expressed at the hearings was that spraying with Baygon may cause cancer or birth defects, rather than its acute toxicity. In addition, concern was expressed about possible ill effects for certain high risk categories in the human population.

Baygon itself has not been implicated at all as a carcinogenic, teratogenic or mutagenic agent. Any concern in that direction relates to nitrosobaygon, that is, Baygon that has been modified by a reaction with nitrogen oxide or nitrite after its release into the environment.

Under certain circumstances nitrosation of Baygon can occur in the urban environment or under conditions that, to a degree, are similar to the conditions found in the human stomach. A number of possible exposure routes have also been identified. Thus far, however, there has been no experimental confirmation that significant exposure to nitrosobaygon is a real rather than a theoretical and hypothetical danger. Additional experiments, such as are being undertaken by Dr. Cummins may provide definite information. At the present time, however, the available evidence suggests that the risk of increased exposure to carcinogens as a result of the emergency spraying is minimal.

In dealing with W.E.E., there is a well-documented and quantifiable risk of permanent disability and death. Even if subsequent research confirms the concerns voiced by Dr. Cummins, the emergency spraying with Baygon would present only a very infrequent, and relatively low risk of exposure to one of the many carcinogens encountered in the modern human environment.

The ultimate decision of how the interests of public health are best protected must be made by the public health authorities, taking all aspects into account. But from the viewpoint of public safety, a decision to use Baygon in order to prevent W.E.E. cannot be regarded as irrational or ill-founded.

Following the hearings, Dr. Peter Warner, Director of Environmental Health, Manitoba Department of Health, submitted a paper to the Commission which examines the health considerations of the use of propoxur as an aerial spray for the prevention of encephalitis. This paper is included in this report as Appendix 5.

There is no evidence to suggest that Baygon is uniformly safe for all persons, regardless of age or physical condition. Indeed, some persons with respiratory ailments might react adversely to inhalation of the insecticide. In addition, some persons may be hypersensitive to the active ingredient or to the carrier.

Two instances were reported at the public hearings by the Provincial Epidemiologist, Dr. Eadie. One concerns an infant in a car that drove through the spray in 1975. The infant went into a state of collapse, was taken to a hospital and resuscitated. The other relates to a young man who experienced weakness and dizziness when driving his car through the spray in 1981. Neither case was followed through at the time to determine with more certainty the cause of the distress. On the other hand, the stories seemed straightforward and reliable. They may well be viewed as evidence of hypersensitivity to either Baygon or to the carrier that was used.

It is important to note, however, that no evidence has been brought forward of any long lasting effects or of permanent disability that can reasonably be attributed to the spraying programs. It should also be noted that exposure to Baygon can be reduced by staying indoors and closing doors and windows during the spraying operations, or by temporarily leaving the area to be sprayed.

It may be concluded that possible adverse effects of the active ingredient or of the carrier on persons at higher than average risk, is not a sufficient reason to avoid using Baygon in the prevention of W.E.E.

### 4-5-4 Environmental Impact

The environmental impact of the spraying operations was monitored in 1975 and in 1981 by relevant departments of the federal and provincial governments. The 1975 monitoring program was rather limited, the 1981 program somewhat more extensive; neither can be regarded, though, as much more than monitoring for readily apparent adverse environmental effects.

Part of the monitoring program was directed at checking for compliance with federal statutes and agreements with federal agencies about the exclusion of certain wildlife reserves. This included a check on rates of application, handling of the chemical, cleanup of spills, disposal of empty containers, etc. There were no problems in this respect; the work was carried out competently and professionally.

Another part of the monitoring program concerned the possible contamination of municipal water supplies. This was checked in 1981 by the Environmental Management Division. Water samples were obtained prior to and 24 hours after the spraying and analyzed for Baygon. In many cases, the Baygon levels were below the detection limit, which is 0.1 parts per billion. Where traces could be found, concentrations ranged from 0.2 to 1.9 parts per billion. The 1978 Guidelines for Water Quality in Canada specifies a limit of 1 part per million as the criterion for safety. The highest observed level was thus a factor of more than 500 less than the safe limit for drinking water.

It is not surprising that no damage to the fish population was observed. With regard to the fisheries, environemntal concerns centre around three aspects:

(1) the bioaccumulation of a compound in the fish that may make the fish unsafe for human consumption.

(2) the toxicity to the fish itself, and

(3) the persistence of the chemical in the aquatic environment that may cause problems later on.

The bioaccumulation of Baygon in the fish is relatively small. Experiments with catfish in water contaminated with Baygon showed that the concentration of Baygon in the fish reached a level of about four times the concentration in the water. This was confirmed by theoretical studies about bioaccumulation. With the low residue levels observed, one may conclude that bioaccumulation of Baygon in fish is not a problem.

With regard to toxicity, numerous tests have shown Baygon to be toxic to fish in concentrations ranging from one to fifty parts per million. The same high safety factor observed in connection with drinking water standards applies here as well.

The persistence of Baygon in water depends on many factors. However, the low residue levels observed and the low frequency of spraying makes the problem rather academic in this case.

In summary, there is no reason for concern about the direct impact of the spraying on the fish population.

Indirect effects could be more serious. Fish are dependent on aquatic insects. These could definitely be killed by Baygon at the concentrations mentioned for the higher observed residue levels during the 1981 program. This factor should, therefore, be taken into account when aerial spraying operations are conducted and when details are worked out.

Much attention was given at the public hearings to the effect of spraying on birds. Birds may be exposed through ingestion, inhalation and by contact with the pesticide. Experiments have produced toxicity levels for each of these exposure routes. But it is very difficult to assess what the actual exposure is when aerial spraying is carried out.

The Canadian Wildlife Service conducted a limited survey of songbird populations at the time of the 1975 spraying. No dead birds were found. In 1981, a small number of dead birds were sent to the Service to determine cause of death. At the time of the hearings, no results were available. As a result, there is still some uncertainty as to the risk to birds; however, there was no evidence of a bird kill. Considering that the objective of the spraying was the prevention of a potentially debilitating and sometimes fatal disease, the impact on the bird population cannot be regarded as prohibitive.

Spraying with Baygon will have a serious effect on all kinds of inseccts, beneficial as well as harmful. Special attention must be given to damage to honeybees and other pollinators.

The 1981 spraying program was monitored by the apiculture staff of the Manitoba Department of Agriculture. The monitoring program consisted of:

(1) a check on the direct effect of spraying on honey production from continuous weight records kept of selected colonies (scale colony records);

(2) caged bee trials, mentioned earlier in connection with the problem of unequal distribution of the insecticide;

(3) direct observation of bees collected in a sprayed sunflower field near Virden;

(4) a comparison of honey production of colonies that had been moved out of the sprayed area with those that had been left;

(5) a comparison of honey production in colonies that had been screened to prevent flight during the spraying with unscreened colonies;

(6) an analysis of the result of a questionnaire sent to all beekeepers.

Monitoring showed severe mortality among bees, especially when the spraying was carried out in the late afternoon. The insecticide also disrupted the social behaviour of the colonies and caused the bees to become agitated and aggressive. Both factors resulted in a significant reduction in honey production.

Moving the colonies temporarily out of the area to be sprayed reduces the damage but does not eliminate it because of the disruption caused by the move. This option also involves much work and is often not available.

Screening the hives will prevent the bees from being killed by the spray. But the screening causes considerable stress, oxygen deficiency and possibly overheating of the colonies. In some instances, the overheating actually caused the wax inside the hive to melt so that wax and honey drained out of the front of the hive. The stress caused by screening is probably the reason why in time the screened colonies did not produce significantly more honey than many unscreened ones.

Honey production is an important industry in Manitoba. Over 1500 beekeepers produced almost $11 million worth of honey in 1981. The damage claimed by beekeepers as a result of the 1981 spraying was estimated at $87,455.00.

Damage to bees could be prevented if spraying were to be conducted before eight in the morning or after nine in the evening since most bees are then in their hives. Unfortunately, aerial spraying must be carried out during daylight hours because of airplane safety and insurance requirements. The closer the operation can be towards the early morning and the late evening, the less will be the adverse impact to bees. This timing would also increase the effectiveness of the spraying since mosquitoes show their greatest activity around sunset and sunrise.

The magnitude of an aerial spraying operation makes it impossible to prevent all damage to beekeepers. However, every effort should be made to keep the beekeepers fully informed of the spraying program and of any last minute changes that are necessary because of weather conditions.

No information is available on the impact of aerial spraying with Baygon on other beneficial insects. Undoubtedly, many are killed. But the area to be sprayed is limited and insect populations often show great resilience in recovering after having been decimated by natural causes. One would expect, therefore, that the effect of spraying will be severe but temporary. This is, of course, confirmed by the observed impact of spraying on mosquito populations.

## 4-6 Conclusions

### 4-6-1 General

Reducing the exposure to infected biting mosquitoes is presently the only way of reducing the incidence of W.E.E. This situation is unlikely to change soon; it is unlikely that a vaccine, suitable for mass immunization, will be developed in the near future.

Reducing exposure is of particular importance for infants under the age of one. As a rule, permanent disabilities occur most frequently, and are most serious, in this age group. There is general agreement that relatively simple protection measures can practically eliminate the risk of infection with WE virus. Any W.E.E. prevention program should, therefore, place a high priority on the promotion of personal protection, particularly for infants.

Aerial spraying with Baygon under the right circumstances has been shown to be capable of decimating an infected mosquito population that is searching for blood meals. This evidently reduces the risk of infection with WE virus.

The effect of aerial spraying with Baygon on human health and on nontarget species is not a matter to be dismissed lightly. Careful consideration, however, shows that the risk of serious and permanent ill-effects is extremely small with a properly conducted aerial spraying program. There is no evidence suggesting that it could even remotely compare with the risk posed by W.E.E.

The decision whether or not to spray must, therefore, be made solely on the basis of efficacy in reducing the incidence of W.E.E.

The effectiveness of aerial spraying with Baygon cannot be taken for granted. It is very much dependent on the mosquito population dynamics and on weather conditions, both of which are to a degree unpredictable. There is strong evidence that the 1981 spraying program was quite effective in reducing the risk of infection, much more so than either the 1975 or the 1977 programs. It is also clear from the record that aerial spraying did not prevent all cases of W.E.E. even in 1981 when conditions for spraying were excellent.

It would be wrong, therefore, to overemphasize the role of the emergency spraying operations in a W.E.E. prevention program. This could create the impression with the public that spraying will take care of the threat of W.E.E. Such an impression could dangerously weaken the other component of the W.E.E. prevention program, the promotion of personal protection.

It appears that, in the public mind, the W.E.E. prevention program has become identified completely with the emergency spraying operations. This is already evident from the extensive documentation of the 1975 epidemic in the Canadian Journal of Public Health of May/June, 1976, which devoted all of its 61 pages to articles about the epidemic and the monitoring and spraying. Apart from a very brief mention of the precautions recommended by the Acting Minister of Health, the personal protection aspect is not even mentioned.

The recently held public hearings were also replete with reports on the safety and the effectiveness of the spraying and with information about side effects on reservoirs, on birds, fish and bees. But, apart from a few speculative and anecdotal remarks about public attitudes toward the need for personal protection, this very important aspect of W.E.E. prevention was not reported on. While it was mentioned several times that personal protection can prevent infection, there was no mention of ways and means of increasing public awareness and of promoting this way of preventing W.E.E.

It is also of interest to note that during the 1981 epidemic the attention of the media was focussed on the spraying and the risk posed by Baygon rather than on the residual risk posed by W.E.E.

It is not suggested at all that the public health authorities were remiss in 1981 in not sufficiently warning the public of the risk of W.E.E. Indeed, it must be acknowledged that a great deal of effort went towards such warnings. But there is very little evidence that the warnings had much effect. Indeed, there are indications to the contrary. It is suggested that research aimed at making the personal protection campaign more effective is not less important than research aimed at increasing the effectiveness of spraying.

The general conclusion, therefore, is that aerial spraying operations with Baygon have a place in the W.E.E. prevention program when the risk of infection with WE virus is high and the conditions for spraying are suitable. The W.E.E. prevention program should be focussed more clearly on the need for personal protection and on protection of infants.

### 4-6-2 The Personal Protection Program

There are good reasons why in recent epidemic years the promotion of personal protection against W.E.E. may have had little impact on public attitudes. General warnings, addressed to the entire Province, convey the impression of a rather remote danger and a prolonged state of alert taxes short memories.

A personal protection campaign is not very exciting compared with the action, the drama and the controversy that surrounds the aerial spraying operations. Moreover, a static state of emergency, that drags on for weeks without any apparent shift in risk, soon ceases to be of interest. Then it is forgotten and public attention is directed towards the Baygon controversy. When those opposed to spraying emphasize the dangers of Baygon and those in favor stress the effectiveness of the program, the risk of W.E.E. that remains in spite of the spraying does not receive much attention.

It is possible that greater public attention and interest would be obtained if the arbovirus surveillance program was expanded sufficiently to provide early identification of specific high risk areas and if an alert was proclaimed only for those specific areas of immediate high risk. It is anticipated that a developing state of risk would hold public attention better than a basically static, prolonged state of emergency.

At this point, a public information program, designed to create an awareness of the seriousness of the danger and the need and responsibility of individuals to personally protect themselves, might achieve good results. Such a public awareness program could be developed by professional public relations people working with the Arbovirus Surveillance Committee. This program might commence with a detailed description of the disease and its serious consequences on its victims, followed by details of the simple and effective measures which people can take for protection. The object of the program would be to increase public awareness and preventive action without creating unnecessary alarm.

Large segments of the population will undoubtedly continue to ignore the warnings even with the best public awareness program. That, however, does not diminish the need for an effective warning system. Moreover, a large percentage of the more tragic consequences of W.E.E. can be prevented, even if nothing more is achieved than effective protection of infants.

### 4-6-3 The Aerial Spraying Program

After all that has been said about the aerial spraying program, the conclusions can be brief.

The entire W.E.E. control effort pivots on the Arbovirus Surveillance Program. This excellent program should be strengthened and expanded to serve both the public alerts that have to be declared and the aerial spraying operations. Continuity is essential for progress in the continuing effort of improving the guidance which the program lends to the control operations.

There is at the present time no safe and effective alternative to aerial spraying with Baygon as a means of curtailing the number of infected, biting mosquitoes, when a W.E.E. epidemic threatens. The available evidence shows that the spraying is capable of decimating a mosquito population. Improved monitoring programs are needed to confirm the effectiveness under operational conditons. Particular areas of uncertainty are the effect of unequal distribution and dispersal of the insecticide.

The probable impact of spraying operations on the course of an impending W.E.E. epidemic remains a matter of considerable controversy. It is unlikely that this issue can be resolved without more knowledge of the WE cycle in Manitoba and without more epidemiological research including the extent and geographical distribution of antibodies in the human population. Research in these areas is urgently needed. Since the WE virus appears to be endemic in Manitoba and the epidemics caused by it are predicated on Manitoba conditions and vectors occurring in Manitoba, it is quite unlikely that research in other jurisdictions will provide the necessary answers.

At the present time, there is no evidence that would suggest that aerial spraying with Baygon poses health hazards that are even remotely comparable to the hazards posed by a W.E.E. epidemic. Some individuals, however, may be at a greater risk because of hypersensitivity or preexisting disorders. Every effort should be made, therefore, to inform the public of the times and locations of intended spraying operations so that people can take the necessary steps to avoid exposure, if desired.

The liaison with beekeepers prior to spraying should be reviewed. Arrangements satisfactory to all parties should be made well in advance of spraying operations.

There is some uncertainty about the impacts of aerial spraying with Baygon on birds and on the aquatic insects that may be important for fish. These should be investigated.

In its interim report, dealing with the emergency mosquito control program to combat encephalitis, the Commission noted that the effectiveness of the program varied significantly from point to point. For this reason, it recommended the implementation of a monitoring program designed to confirm that aerial spraying is effective for its intended purpose and to improve the efficacy, where possible. The Commission also recommends that an expanded monitoring program provide better assessment of the environmental impact of the spraying program. A complete and comprehensive monitoring program should be designed and made ready for implementation so that any last-minute improvisations will not be necessary, should a future encephalitis outbreak necessitate an aerial spray program.

# SECTION 5

## LEGISLATIVE CHANGES

### 5-1 General

In his letter requesting the investigation, the Minister asked the Commission to review the existing legislation and procedures and to make recommendations as to what changes in provincial legislation may be required.

Complying with this request necessitates an analysis of the problems encountered and the criticism voiced about current legislation and practice. These problems and criticisms pertain mainly to the control of nuisance mosquitoes. Emergency spraying operations are in a somewhat different category. While one may disagree with them, there is an obvious need for legislation that enables the government to take effective and speedy action in case of an emergency, whatever that emergency may be. Legislation concerning emergencies must be couched in very general terms. It must be aimed at allowing action rather than aimed at control of the action. The question addressed in this section is, therefore: "Does the present legislation in Manitoba adequately regulate the use of insecticides in the control of nuisance mosquitoes?"

A review of the legislation in neighbouring jurisdictions is very useful when attempting to answer this question. Representatives of the provinces of Ontario, Alberta, and Saskatchewan spoke at the hearings and outlined not only how mosquito control programs are regulated in their provinces, but also how this regulation works in practice. This provided a very valuable basis for comparison and greatly assisted in the evaluation of the Manitoba legislation and practice.

The discussion of this section starts with an analysis of the Manitoba situation. The regulation here is then be compared with that in the neighbouring provinces. Finally, conclusions are presented that will lead to the recommendations listed in Section 6.

## 5-2 Regulation of Mosquito Control Programs in Manitoba

The following acts regulate mosquito control programs in Manitoba:

1) The Federal Pest Control Products Act and the regulations thereunder,

2) The Manitoba Pesticides and Fertilizer Control Act, and

3) The Clean Environment Act with its regulations.

The Pest Control Products Act basically regulates the sale and distribution of pest control products. The Act controls label instructions that define appropriate and safe conditions of use. It makes handling and use of pesticides under unsafe conditions an offense. It is the first line of defense in ensuring safety in the use of pesticides.

The Manitoba Pesticides and Fertilizers Control Act requires the dealers and the commercial applicators to be licenced under the provisions of this Act. It also requires that records on supply, sale and use be kept by dealers and applicators. As this Act provides little more than registration it is not particularly important to this discussion.

The most important piece of environmental control legislation in Manitoba is The Clean Environment Act. This Act requires any person who intends to discharge contaminants into the environment to first file a proposal with the department responsible for the administration of the Act, unless exempted by Section 14.1 or by the Regulations.

If an exemption is not sought, or is not possible, then the proposal sets in motion a departmental review of the proposal. The proposal is then placed before The Clean Environment Commission who will then decide on appropriate conditions and limits for the operation and issue an Order to that effect. The application for an order is advertised and any intervenor can, by stating his or her desire to make a representation, make a public hearing mandatory. The Commission can also hold a public hearing on its own accord. When this route is followed, the Commission order regulates the operation with the force of law. Appeal may be made to the Minister within 30 days of the issuance of the order.

Section 14.1 allows an exemption, which is available to municipal corporations. In the event that there are no demonstrable effects of the proposed operation beyond the boundaries of the municipality, the municipality may, rather than file a proposal, file with the Department a statement outlining the program and an environmental impact statement about the possible environmental effects within and beyond the municipal boundaries. The municipality can then proceed with the program without referral of a proposal to The Clean Environment Commission.

Manitoba Regulation 156/74, which is a regulation under The Clean Environment Act, also contains exemptions. It allows agricultural producers and households to apply pesticide on property that is owned or under their control; it also allows persons to apply pesticide on behalf of a Government Department, Crown Corporation or Municipal Corporation in order to conform with the Noxious Weed Act, or to apply pesticide on an area not designated as residential or recreational. Finally, it allows the Minister to respond to a health emergency declared by the Minister of Health, by waiving all regulatory requirements.

Criticism of this legislation has focussed on the two options available to municipalities that wish to conduct mosquito control programs in residential or recreational areas. The route via The Clean Environment Commission is one that allows all desired environmental safeguards to be incorporated in the orders issued by the Commission. It also provides for full public participation in the decision making process. However, the route is detailed, time consuming, costly and more appropriate for individual operations that pose their own environmental problems and require tailor-made regulatory control. It is not particularly suited for annual repetitive operations.

The route specified in Section 14.1 of The Clean Environment Act, on the other hand, leaves control of the program in the hands of the municipality, always, of course, within the confines of federal legislation. This raises the question whether Section 14.1 adequately reflects the responsibility which the Provincial Government has for public health and for the environment.

The intent of the exemption under Section 14.1 is to allow a municipality the option of judging for itself whether the benefits of a control program outweigh the risk to human health or to the environment within the boundaries of the municipality. The rationale behind the exemption is, evidently, the consideration that major health concerns are being taken care of by the federal legislation. The decision to spray or not to spray is, therefore, seen as a political decision, which can be made competently at the municipal level. Presumably, such a decision would then reflect the preference of the majority in a controversial issue that cannot be decided on objective grounds.

In principle, this position appears to be sound. It is in harmony with established attitudes vis-a-vis pesticides in other situations. For example, agricultural producers, or any private persons, are allowed the use of registered pesticides, provided they keep everything on their own property and do not expose their neighbours to the chemicals. It is understood that the users realize the need for caution; it is taken for granted that they will not waste their money on ineffective operations; it is assumed that they accept whatever risk is associated with the handling and use of the insecticides.

Yet there is a need to differentiate between actions of individuals that presumably do not concern others and actions by municipalities in the public domain. Regardless of municipal responsibilities, the residents, and others that happen to be there, are entitled to seek from the provincial government the necessary protection of their health and the natural environment; for those are provincial responsibilities. The problem is not that the municipalities are given the authority to decide whether or not to have mosquito control programs within their own boundaries, but that the Act does not provide the Provincial Government with a means of asserting its overriding responsibility for health and the environment, should this become necessary.

It has been argued that the Provincial Government still exercises control over the operation because Section 14.1(1) requires the municipality to file with the Department an environmental impact statement, containing a detailed assessment of the possible effect of the program on the environment within and beyond the municipality, in accordance with guidelines supplied by the Department.

There is nothing in the Act that requires approval of the impact statement or of the proposed operation. Once the statement is filed, according to the guidelines, there is nothing further required of the municipality, nothing that stands in the way of carrying out the program.

This view is supported by the fact that the obvious intent of the exemption is to leave the decision in the hands of the municipality. Indeed, the only section in 14.1 that refers to the power of the Minister to intervene, is Section 14.1(4) which states that the Minister may order the municipality not to begin or to cease the program, where he is of the opinion that the program is likely to have a demonstrable effect on the environment beyond the municipality. It may be argued that the primary purpose of the environmental impact statement is to allow the Minister to ascertain whether or not effects are fully contained within the municipal boundaries.

Practice also supports this view. Since Section 14.1 has come into force, the Environmental Management Division has taken the position that it will not interfere with any proposed program provided it represents a use of the pesticide that is registered by the Federal Government. In this respect, the Division acts merely as a watchdog for the Federal Government, since the use of a pesticide contrary to label instructions is a federal offense. It, therefore, appears that the provincial legislation needs to be tightened up to permit provincial intervention, should this prove to be necessary.

The present legislation assumes that municipalities have the expertise and the resources to design safe and effective mosquito control programs, that they can prepare a meaningful environmental impact statement and that they can execute a control program safely, effectively and efficiently. In fact, very few municipalities have that capability readily available.

In this connection, it is worth noting that several speakers at the public hearings considered operator error to be the greatest hazard associated with the use of chemical pesticides.

It is true that municipalities can elect to submit a proposal that brings the matter before The Clean Environment Commission. But that does not solve the problem of designing an effective program, nor does it automatically result in a safe and effective execution of the program.

A related problem is the fact that the legislation contains no requirement that municipal operators of mosquito control equipment, or the supervisors in charge of the operations, obtain any special training. The Manitoba Pesticides and Fertilizers Control Act requires dealers and commercial applicators who work in nonresidential and nonrecreational areas to be licenced. It is inconsistent to allow untrained persons to disperse chemical insecticides in residential and recreational areas, let alone to design and control such operations.

Finally, it may be mentioned that The Clean Environment Act and its Regulations do not address the special situation of private property to which the public has free access or to which the public may be invited. It would seem that the Regulations exempt the owner from submitting a proposal under Section 14 (1) and allows him to do as he, or she, pleases within the confines of the property. The public use made of the property, rather than the ownership, should determine the control needed to safeguard the public interest. Private property not accessible to the public at large is obviously a different matter.

In summary, it appears that there is a need for legislative changes that will provide the Provincial Government with the means of regulating the planning, designing, and implementing of mosquito control programs in the interest of the environment and of public health. There is also an urgent need for means of increasing the expertise and the resources at the municipal level that will make safe and effective mosquito control programs possible, not only in a few large municipalities but right across the province.

## 5-3 Legislative Control in Other Provinces

Information about provincial regulation of mosquito control programs was obtained from the Provinces of British Columbia, Alberta, Saskatchewan, Ontario, Nova Scotia and New Brunswick. In addition, representatives from the Provinces of Alberta, Saskatchewan and Ontario were present at the public hearings and provided more detail about practices in their provinces.

In each of these provinces, municipalities must obtain a licence or a permit to conduct a mosquito larviciding program. The application for a permit or a licence must contain adequate information about the program. Furthermore, in some provinces, the permit or licence states the conditions that must be met in the execution of the program.

Each of the provinces mentioned above requires applicators of the insecticide to be licenced for both larviciding and adulticiding. It can thus be seen that all provinces have the means of exerting a tighter control over the operations than Manitoba can exert.

Actual practice, of course, differs somewhat from one province to the next as was evident from the information presented at the public hearings.

In the Province of Ontario, the authority to control lies with the Pesticides Control Section of the Ontario Ministry of the Environment. The authority is derived from the Pesticides Act.

The Act gives the private home owner the right to apply pesticides, on his or her own property, provided the pesticides are registered for the intended use. The Act does not permit the application of pesticide on any water from which there may be surface runoff beyond the property. A similar clause is found in the present Manitoba regulation.

With respect to municipalities, the decision to set up a mosquito control program is a political decision that is made at the municipal level. But the Ontario Government exercises control over the efficacy and the safety of the program. It does this in the first place by issuing permits for the mosquito larviciding programs.

In order to obtain a permit, the municipality must provide detailed and accurate maps of the sites that are to be treated. Dip tests must be conducted prior to treatment to ascertain the number of larvae. Chemical compounds used and dosage must be in accordance with federal registration. After larviciding, there must be an evaluation of the effectiveness on the basis of additional dip tests. The Ministry of the Environment has the right to inspect the programs at any time. Finally, at the end of the season, a detailed report must be filed about the operation, without such a report the municipality will not get a permit for the following season.

The Ontario legislation also requires the supervisor of the mosquito larviciding program to be a licenced operator, with an aquatic exterminator's licence, Water Class III. This licence must be endorsed for mosquito larviciding. A licenced supervisor may have up to three unlicenced operators working under him. If there are more unlicenced operators, then there must be more licenced supervisors. In order to obtain a licence, the individual must take a self-training course and pass a written examination with at least a 75% mark. The examination is quite comprehensive and includes the legal acts and regulations to be followed, the interpretation of the label information, the biology of the mosquitoes, safety factors, techniques of dilution and rates of application, etc. If the supervisor is involved in an adulticiding program, then he needs an exterminators licence

Land Class 10, which is to be endorsed for mosquito adulticiding. This also requires a course and an examination along the same lines as described above, but with particular application to adult mosquito control.

The Ministry of the Environment in Ontario provides the municipalities with technical assistance, for example, in the identification of mosquito species, in providing New Jersey light traps, etc.

There are not many major mosquito control programs in Ontario. The cities of Windsor and London have comprehensive larviciding and adulticiding programs. Mosquito control programs for cottage developments have been set up by some townships. One of these carries out an adulticiding program only.

In the Province of Alberta, the major emphasis is on larviciding. Under the Agricultural Chemicals Act, a community wishing to conduct a mosquito abatement program must get a permit to apply pesticide on, in or near water. The permit is issued by the Pesticide Chemicals Branch, Pollution Control Division, Alberta Environment. In order to obtain such a permit, three basic requirements must be met.

The program must, first of all, be under the supervision of a person with a Class L applicator's licence. To get such a licence, the person must follow a course and pass an examination similar to what has been described for the Ontario licence.

The second requirement is the preparation of detailed maps of the area to be treated. Such maps must show the location of mosquito breeding sites within several miles of the community. The sites must be classified according to their productivity in breeding mosquitoes. The map must also locate sensitive areas, such as fish farms, beekeeping operations, etc., and the property of persons opposed to treatment of their property. Finally, the maps must contain information on adult harborage sites, wood lots, areas with tall grass, vacant lots, etc., that provide shelter for adult mosquitoes and, therefore, attract relatively large numbers of them. It is understood that an adequate map cannot be prepared in a single year. But by observation and successive improvement, a satisfactory map can be obtained in three to four years. The requirement of adequate mapping is very strict: no map, no permit.

The third requirement is that a detailed annual report is prepared at the end of each season.

The Province of Alberta complements legislative control with financial assistance to approved mosquito abatement programs. Last year a

Actual practice, of course, differs somewhat from one province to the next as was evident from the information presented at the public hearings.

In the Province of Ontario, the authority to control lies with the Pesticides Control Section of the Ontario Ministry of the Environment. The authority is derived from the Pesticides Act.

The Act gives the private home owner the right to apply pesticides, on his or her own property, provided the pesticides are registered for the intended use. The Act does not permit the application of pesticide on any water from which there may be surface runoff beyond the property. A similar clause is found in the present Manitoba regulation.

With respect to municipalities, the decision to set up a mosquito control program is a political decision that is made at the municipal level. But the Ontario Government exercises control over the efficacy and the safety of the program. It does this in the first place by issuing permits for the mosquito larviciding programs.

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The third requirement is that a detailed annual report is prepared at the end of each season.

The Province of Alberta complements legislative control with financial assistance to approved mosquito abatement programs. Last year a total of $578,000 was spent on financial assistance to 31 mosquito abatement programs. Financial assistance is a powerful tool in controlling the safety and efficacy of mosquito abatement programs. The representative for the Province of Alberta pointed out at the hearings that the Province was not about to provide financial assistance to a community that does nothing but adulticiding.

Control strategies vary considerably across the Province of Alberta because of the vast differences in local conditions, which range from dry prairie or irrigation districts to communities surrounded by bush and marsh. It should be mentioned, however, that no community in Alberta practices adulticiding in residential areas. Adulticiding is limited to the so-called harborage sites of adult mosquitoes.

Mosquito abatement programs in Saskatchewan have been left largely to the municipalities with a minimum of provincial control. Programs are not centrally monitored as in Alberta and Ontario. The Saskatchewan Department of the Environment issues permits for larviciding and the Department of Agriculture licences the applicators who apply the chemical. No permit is required for adulticiding provided the insecticide is not applied over water.

## 5-4 Conclusions

Comparing the principal features of the Manitoba legislation with the regulatory control exercised by other provinces suggests a number of improvements that could be implemented.

1. There appears to be a need for improved provincial control in areas of provincial responsibility that are connected with municipal mosquito abatement programs. At the present time, the Provincial Government may not even have the power to intervene, namely, if the municipality elects to proceed under Section 14.1 of The Clean Environment Act, files an environmental impact statement as required under Section 14.1 (1)(d) and sticks to the project description it has provided in compliance with Section 14.1(1)(c). The point is not whether such an intervention is likely to be needed now or in the future; it is that legislation should clearly provide the

Provincial Government with the power to intervene in matters where it has an overriding responsibility.

2. The Environmental Management Division should be given a much more meaningful role than that of checking for compliance with federal legislation. There are compelling reasons for doing so:

Firstly, proposals submitted by the municipalities should be checked for efficacy and for safety; this check should become the basis for approval or disapproval. Efficacy in this connection is not so much a matter of economics but of ensuring prudent use of poisonous chemicals in the environment; that use ought to be justified by the beneficial effects obtained.

Secondly, it should be recognized that the design of effective and safe mosquito abatement programs requires resources and a degree of expertise not available to all municipalities that need mosquito control. The Environmental Management Division should provide the municipalities, that need it, with the necessary technical assistance, as is done in the Provinces of Ontario and Alberta.

Thirdly, the mosquito control programs must be monitored for two important reasons. The first reason is to ensure that safe procedures and sound environmental management practices are followed. This means that the Division must have the right to inspect the program at any time. It also means that reports on the operation and the effectiveness as determined by prescribed procedures must be made available to the Division. The second reason for monitoring is that effective abatement programs do not spring up full-fledged but must be developed and improved over a number of years and continually adapted to new information and changed circumstances.

It is acknowledged that some municipalities, particularly the cities of Winnipeg and Brandon, have excellent abatement programs under the supervision of competent entomologists. But including them in the general supervisory responsibility of the Division works no hardship on them and has the advantage of bringing about contacts between experts in the field of mosquito control that may prove beneficial to all.

3. The route via The Clean Environemnt Commission is not the most desirable way of dealing with the routine problems associated with mosquito control programs. Many public hearings have already been held on the subject and it is difficult to argue that this consultative process must continue indefinitely, or that anyone should be able to initiate it for every new order dealing with mosquito abatement. Moreover, The Clean Environment Commission can always initiate public hearings, should changed circumstances or new evidence make this desirable. Such hearings can also be initiated by the Minister.

4. A permit system, such as is in operation in Alberta and Ontario, would be an improvement. This single route would then replace the two options presently available. There appears little justification for a distinction between larviciding programs and adulticiding programs in this regard. A permit should be required.
   Conditions vary greatly for municipalities across Manitoba. Mosquito abatement programs must reflect this. For this reason, it is probably not possible to develop general guidelines that cover all eventualities. It would seem best, therefore, to issue with each permit a set of conditions that must be met and that form part of the permit.

5. Some thought should be given to the protection of private persons who object to having their property treated either in a larviciding or in an adulticiding operation. In the privacy of one's home or one's property, one should have the right to be free of unwelcome intrusions that could conceivably be harmful to sensitive individuals. It also seems evident that this is not an absolute right and that it should not be allowed to stand in the way of programs aimed at preventing an epidemic such as W.E.E. It is perhaps more difficult to argue that objectors should not be exempted because that reduces the effectiveness of a nuisance abatement program. Mosquitoes may be a terrible nuisance but it is not self-evident that a person

has the right to a maximum abatement of the nuisance. Neither is it self-evident that the public interest is better served by maximizing mosquito control than by the protection of individuals from interference with their property. It is, therefore, suggested that the permit conditions contain criteria about the nuisance level that justifies adulticiding in residential areas as well as criteria that provide a reasonable protection for the objectors against the drifting of the drifting of insecticide onto their property in excess of stated limits.

6. Licencing of supervisors and operators is needed in the interest of efficacy and safety. The practice in the Provinces of Alberta and Ontario, and elsewhere, should be examined in more detail to determine the most advantageous method of accomplishing the objective. Two level licencing, one for supervisors and the other for operators of equipment, may be the best solution. A training program, developed and conducted by the Provincial Government, is an essential part of the licencing procedure.

# SECTION 6

## RECOMMENDATIONS

1. The Commission recommends that a scientific investigation of the long-term effects of propoxur residues and breakdown products from both aerial and ground based mosquito adulticiding programs be carried out by federal and provincial health and environmental authorities. Such a study should provide authoritative reassurance as to the safety of the use of propoxur, or alternatively, the extent of any hazards that may exist.

2. The Clean Environment Act should be amended to require that every municipality must obtain a permit from the Government of Manitoba before conducting a municipal mosquito control program using insecticides. Permits should be issued annually and may include terms and conditions. Mosquito control programs should only be carried out in accordance with the terms of the permit.

3. Permits should also be required for mosquito control programs conducted on private property to which the public normally has access, such as golf courses, campgrounds, and mobile home parks.

4. An application for a permit should be accompanied by a complete description of the proposal which should include:

   (a) a detailed map of the areas to be treated in the mosquito control program;

   (b) a list identifying the operators and their qualifications, the equipment and the insecticides to be used;

(c) an outline of the conditions to be followed such as timing, frequency, larvae counts, methods of public notification, which describe the proposed operation.

5. Public notice of each permit issued should be advertised in the appropriate newspapers.

6. Any person directly affected should have the right to appeal the permit issuance to the Minister and the Minister should be enabled to:

(a) suspend or cancel the permit;

(b) deny the appeal;

(c) refer the matter to The Clean Environment Commission to hold a hearing and make recommendations to the Minister or, by order, amend, cancel, or confirm the permit as issued.

7. Where a permit application is denied by the issuing authority, the applicant should have the right of appeal to the Minister and the Minister should be enabled to:

(a) approve the application;

(b) deny the appeal;

(c) refer the matter to The Clean Environment Commission to hold a hearing and make recommendations to the Minister or, by order, amend, cancel or confirm the decision that a permit be denied.

8. At the conclusion of each mosquito control season, the applicant should submit a report summarizing the program with particular emphasis on efficacy with a view to adopting desired improvements in subsequent years. The submission of such a report, in a form satisfactory to the receiving authority, should be a prerequisite to the issuance of further annual permits.

9. Terms and conditions that should normally be included in mosquito control permits are:

   (a) adulticiding must normally be confined to parks and recreation areas and should not include residential areas;

   (b) residential adulticiding shall be conducted only when mosquitoes create exceptional nuisance conditions (as determined, for example, by bite count or mosquito trap data) and as defined in the permit;

   (c) a larvicide program carried out as authorized in the permit shall be a precondition for the operation of any adulticide program in a residential area;

   (d) residential adulticiding shall not be conducted when weather conditions are unsuitable as outlined in the permit;

   (e) the municipality shall provide adequate notification of proposed adulticiding operations as required in the permits;

   (f) the municipality shall give each occupant of residential property the opportunity to object in writing to the inclusion of that property in the residential adulticiding program;

   (g) the municipality shall take all reasonable precautions to ensure that the insecticide will not encroach onto the property of persons who have filed objections;

   (h) the applicant shall be required to maintain a high standard of equipment calibration and maintenance.

10. The province should develop and conduct a training program for operators and supervisors involved in mosquito control programs.

11. All operators should be licenced. The training and periodic refresher and updating courses should be a prerequisite for licencing and licence renewal.

12. With respect to emergency insecticide programs for the control of western equine encephalitis, the Commission confirms as final the interim conclusions and recommendations contained in its "Interim Report on Mosquito Control Programs in the Province of Manitoba", attached as Appendix 2. This report dealt only with the emergency aerial spraying mosquito control programs which were conducted to control the spread of western equine encephalitis during epidemic conditions.

13. Public relations expertise should be obtained to develop, in conjunction with the Arbovirus Surveillance Committee, a program designed to heighten public awareness of the need for personal protection in the event of a renewed western equine encephalitis emergency program.

## SECTION 7

## GLOSSARY OF TERMS

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| Abate (temephos) | Larvicide available in granules or emulsifiable concentrate for mosquitoes, blackflies, etc. |
| Active ingredient | That component of an insecticide which is toxic to insects as opposed to the diluents, carriers or emulsifiers that may be present. |
| Adulticide (adulticiding) | Insecticide for the control of adult mosquitoes, or its use. |
| Aerial spraying | The application of insecticide or larvicide as an aerosol, liquid or granular form from rotary or fixed wing aircraft. |
| Arbovirus | The class of viruses which includes the encephalitis (or sleeping sickness) strains that transmit Eastern Encephalitis, St. Louis Encephalitis, California Encephalitis and Western Equine Encephalitis. |
| Arbovirus control program | The aerial application of the insecticide Baygon by the provincial Government to reduce Culex tarsalis mosquito poplations during Western Equine Encephalitis health emergencies. |
| Arbovirus Surveillance Committee, Manitoba | A standing committee of experts formed under the auspices of the Manitoba Health Department to monitor surveillance data and recommend surveillance methods and measures for the control of Western Equine Encephalitis and other arbovirus diseases. |
| B.T.I. | See Bacillus thuringiensis israelensis. |
| Bacillus thuringiensis israelensis (BTI) | A mosquito larvicide which contains spores and chrystalline endotoxin produced in the bacillus, serotype H-14, a microbial product. |
| Baygon (propoxur) | An insecticide (see propoxur). |
| Bioaccumulation (Bromagnification, Bioconcentration) | The phenomenon whereby substances which accumulate in the tissues of planctonic organisms tend to appear in greater concentrations in tissues of the higher organisms in the food chain, for example, bottom feeding fish, predator fish, birds and man. |
| Carbarmate | A fungicide control for scab, mold and rust on apples, etc. |

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| Carcinogen | A cancer producing substance. |
| Chlorpyrifos (e.g. Dursban) | An insecticide used as an adulticide or larvicide for mosquitoes, available in granular or emulsifiable concentrate form. |
| Cholinesterase | A body enzyme necessary for nerve functioning - can be destroyed by organic phosphates or carbamates. |
| Culex tarsalis | The species of mosquito known to be the principal vector for infecting humans with Western Equine Encephalitis virus. |
| Dursban | See chlorpyrifos. |
| Efficacy (of an insecticide) | Degree of relief from biting insect attack attributable to insecticide use. |
| Electrocardiogram (ECG) | An electromechanical means of producing a graphic image of changes in electrical potential used in diagnosing heart beat abnormalities. |
| Encephalitis (Encephalomyolitis) | A class of viral diseases affecting the nervous system and brain in humans. |
| Entomologist | An expert in insects. |
| Environmental Management Division | A division of the Manitoba Department of Workplace Safety and Health, Environment and Northern Affairs. |
| Epizootic | A serious outbreak of disease among animals of one kind. |
| Epidemiology | The study and scientific medical analysis of the incidence, distribution and control of disease in a population. |
| Equine | Pertaining to horses. |
| Fenitrothion | Insecticide for the control of chewing and sucking insects that damage vegetation. |
| Flit MLO | A low viscosity mineral oil used as a mosquito larvicide, blocks breathing at water surface. |
| Fogging | Aerosol dispersal of insecticide either by thermal fogging or ultra low volume (ULV) spraying. |

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| Health emergency | Provision is made in Manitoba regulation 156/74, as amended, issued under The Clean Environment Act, for the Minister of Health to declare an "emergency health situation" and where it is considered necessary to control such an emergency, the minister responsible for the environment is empowered to permit the application of insecticides anywhere in the province. |
| Insecticide | A substance or mixture of substances intended to prevent, mitigate or destroy any insect. |
| Larva | The development stage following the egg and before the pupa in insects such as mosquitoes, moths, beetles, etc. |
| Larvicide | A substance intended to kill larvae of certain insect species. |
| Light trap | A device for the automatic trapping of mosquitoes and other species (other traps provide a carbon dioxide emission as an additional or alternative attractant). |
| Malathion | An organophosphorus insecticide used in fogging, ULV and larviciding operations. |
| Methoxychlor | A chemical insecticide used to control mosquito adults and larvae. |
| Mutagenic | The property of a substance to produce genetic changes in living cells. |
| Nitrosopropoxur or nitrosobaygon | A carcinogenic compound alleged to be formed when propoxur is combined with oxides of nitrogen. |
| Nontarget species | All living organisms not intended to be affected by a pesticide application program. |
| Nuisance mosquito | Biting mosquitoes other than those that carry disease infection. |
| Pathogen | A micro-organism that can cause disease. |
| Pesticide | Any substance that destroys insects, rodents, nematodes, fungi or weeds including defoliants and dessicants. |
| Phytotoxicity | Degree of toxicity to plants. |
| Propoxur (e.g. Baygon) | Carbamate insecticide effective against adult mosquitoes, flies, etc., used as aerosol or fog. |

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| Pupae | Stage of development following larva and preceding adult in mosquitoes and other insects. |
| Pyrethrum (pyrethrin, pyrethrin tossits) | Insecticide from chrysanthemum flower derivative used as a mosquito larvicide. |
| Registration (of pesticides) | A process coordinated by Agirculture Canada whereby a pest product is tested and assessed for efficacy and safety by various departments of the Government of Canada and granted a registration under the Pest Products Registration Act which results in the approval of directions for use, classifications and approval for sale and importation. |
| Resmethrin | A chemical insecticide used as a ULV aerosol for control of adult mosquitoes and other insects. |
| Sentinel flocks | Flocks of caged chickens maintained under a program operated by the Arbovirus Surveillance Committee to monitor Western Equine Encephalitis antibody formation in blood samples. |
| Seroconversion | The change from negative to positive results when a sequence of blood samples is tested for the presence of a specific type of antibody. |
| Spraying | As used in the report the term "spraying" includes aerosol application by ULV and thermal fogging, as well as the spraying of liquid insecticides. |
| Temephos (e.g. Abate) | Larvicide available in granules or emulsifiable concentrate for mosquitoes, blackflies, etc. |
| Teratogen | A chemical that can cause malformations or deviations from normal type. |
| Thermal fogging | Disbursal of an aerosol fog consisting of a mixture of insecticide concentrate with diesel oil formed by means of heated air. |
| Toxic | Poisonous.<br>Acute toxicity - severe cause of poisoning.<br>Chronic toxicity - additive effects of repeated exposure or accumulation of chemical in the body. |

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| U.L.V. (fogging or spraying) | Ultra low volume the use of modern ULV equipment to apply uniform, micron-size, aerosol spray of undiluted insecticide at rates less than 1/2 gallon per acre. |
| Vector | An organism that transmits a pathogen. |
| Virus | A submicroscopic pathogen or causative agent of infectious disease. |
| W.E.E. or W.E. | See Western Equine Encephalitis. |
| Western Equine Encephalitis | A viral disease affecting the nervous system in humans that may cause mental or physical retardation, disability or death. |
| W.E. (or W.E.E.) Cycle | The cycle of this disease implies the maintenance of a reservoir of virus over the winter, probably in a host organism, transfer of the virus to the intermediate hosts (primarily birds) by mosquitoes where amplification of virus numbers takes place, and transfer by mosquitoes to the final hosts - horses and humans. |

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# APPENDIX 1

## LETTER FROM THE MINISTER

MANITOBA

MINISTER OF NORTHERN AFFAIRS
WINNIPEG
R3C 0V8

March 25, 1982

Mr. S. Eagleton
Chairman
Clean Environment Commission
Box 4, Building 2
139 Tuxedo Avenue
Winnipeg, Manitoba
R3C 0V8

Dear Mr. Eagleton:

Since last summer, there has been concern expressed over present mosquito control programs. As a result of these concerns, it is essential that a detailed investigation be carried out to determine the extent of the problem and to develop guidelines or regulations as needed.

As a result of these concerns, I am requesting the Clean Environment Commission to investigate this matter and to hold public hearings pursuant to Section 13(1) of the Clean Environment Act and to provide me with a report and recommendations prior to the next control season.

I would ask the Commission to place emphasis upon, but not restrict itself to:

1. An assessment of existing and potential environmental problems associated with existing control procedures and of alternative methods.

2. A review on the efficacy of existing control methods and of alternative methods.

3. A review of existing legislation and procedures with recommendation as to what changes in provincial legislation may be

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required.

It is expected that the public hearings will provide all interested parties an opportunity to present comments.

Yours truly,

Jay Cowan
Minister

# APPENDIX 2

# INTERIM REPORT
# ON
# MOSQUITO CONTROL PROGRAMS
# IN
# THE PROVINCE OF MANITOBA

# INTERIM REPORT ON

# MOSQUITO CONTROL PROGRAMS IN THE PROVINCE OF MANITOBA

## Introduction

This report is a partial response to the request of The Honourable Jay Cowan, the Minister Responsible for Environmental Management, for a detailed investigation of mosquito control programs in Manitoba. This request was made in a letter to the Commission dated March 25, 1982.

This investigation involved four days of hearings in Winnipeg, including two evening sittings, and one day hearings in Brandon, Dauphin, and Thompson. A large number of highly qualified and respected individuals in the fields of medicine, science, academia, Government (Canada and the Provinces), and the public at large, with practical knowledge of matters being examined, made written and oral representations to the Commission, and a correspondingly very large volume of exhibits, papers, and transcripts of verbal presentations have been received. The deliberations of the Commission, after thorough study and assessment of all this material, will be the basis for a full and detailed report at a later date.

The investigation carried out by the Commission pertains to two separate aspects of mosquito control:

1. the application of mosquito control in the prevention of an outbreak of western equine encephalitis; and

2. the abatement of the nuisance caused by mosquitoes (nuisance mosquitoes).

The first aspect of mosquito control is a rather urgent matter since the Province may, at any time, be faced with another threat of a western equine encephalitis epidemic. For this reason, the Commission decided to deal with mosquito control as related to western equine encephalitis first and to transmit its preliminary conclusions and recommendations on this matter to the Minister in the form of this interim report.

This course of action will enable the Minister to give consideration to the interim conclusions of the Commision should action be required during the summer of 1982 in connection with a western equine encephalitis prevention program.

## Interim Conclusions and Recommendations

The Clean Environment Commission, having considered the evidence presented at the public hearings, has reached the interim conclusion that a program of aerial spraying with the pesticide Baygon is environmentally acceptable at this time, should the Province be faced with a serious threat of an outbreak of western equine encephalitis and should this course of action be recommended by the Manitoba Arbovirus Surveillance Committee.

The Commission also concludes that the present practise of having the Manitoba Arbovirus Surveillance Committee monitor the probability of an outbreak of western equine encephalitis and advise the Government on the need for the implementation of an aerial spraying program be continued.

The Commission has based this position on the following considerations:

1. The evidence presented at the hearings, while based on a rather limited monitoring program, nevertheless adequately indicates that the aerial spraying program conducted in 1981 did reduce the numbers of Culex tarsalis mosquitoes, the major carrier of the virus. This supports the conclusion that the 1981 program reduced the incidence of infections with western equine encephalitis virus. No confirmable evidence to the contrary was submitted.

2. The evidence presented at the hearings also indicates that the 1981 single aerial dispersal of Baygon into the environment, with the low concentration used by the aerial spraying program, posed no appreciable threat to human health or to fish and wildlife. Significant damage to nontarget species was reported only for honeybees. There were, however, concerns expressed by some persons at the hearings about adverse long-term effects of repeated chemical applications and the accumulation of any residuals.

3. The Arbovirus Surveillance Program was an effective tool for judging the severity of the threat of a western equine encephalitis epidemic. It constituted an excellent means of bringing together those government officials that have a primary responsibility in this area and a number of experts who need to be consulted. In a multifacetted and uncertain situation, this arrangement appears to be the best and most suitable means of providing the government with responsible professional advice based on a balanced judgement.

## Additional Conclusions and Recommendations

Decisions must be based on the best available evidence, even though the evidence is not always complete or conclusive. The Commission recognizes the serious questions and concerns that were raised at the public hearings about the suitability of the aerial spraying program in the control of western equine encephalitis. For this reason, the Commission wishes to present the following additional conclusions and recommendations:

1. The direct evidence for the effectiveness of the aerial spray program in reducing the population of Culex tarsalis, although positive, is based on a limited number of tests. There are also indications that, in some areas, the effectiveness varied significantly from point to point. There is a great need for a properly designed monitoring program, firstly, to confirm that aerial spraying is indeed effective and, secondly, to improve the efficacy where possible.

2. An aerial spray program will not eliminate the risk of an infection with western equine encephalitis even in the areas that are covered by the program. In the rural areas that are not sprayed, the risk remains. It is important to realize, therefore, that personal protection against mosquito bites offers the most effective way of reducing the risk anywhere. Previous experience, however, shows that it is difficult to alert and convince the general public of the need for personal

protection, even though the measures recommended were rather simple. The Commission, therefore, recommends that methods of increasing public awareness for the need of personal protection be studied and developed and that an intensified program should be a part of any future aerial mosquito control spray program.

3. A vaccine for the control of western equine encehalitis has received attention but with limited success. Unfortunately, this vaccine is not suitable for mass vaccination nor is it suitable for immediate immunization at the time when an epidemic is identified. Neither is it presently available for general use. While it is probable that a vaccine could be developed that would be suitable for mass immunization, it is unlikely that the development would be undertaken by the private sector without further government incentives. The limited distribution of the western equine encephalitis disease and the infrequent occurrence of epidemics discourage private initiative in this area. In view of the seriousness of the disease, the limited protection offered by mosquito control programs and the objections to the aerial application of pesticides, especially in residential areas, the Commission recommends that serious consideration be given to the possibility of encouraging the development of a suitable vaccine by the senior governments.

4. The Federal Government officials, responsible for pesticide registration and testing, present at the hearings gave evidence to the Commission that Baygon is environmentally acceptable for aerial spraying when used in accordance with authorized dosage directions and application procedures for this purpose. Nevertheless, the possibility exists that exposure to aerial spraying may adversely affect persons in a high risk category, particularly those persons with respiratory diseases and those with an unusual sensitivity to the chemical. The Commission does not consider this sufficient reason for disallowing aerial spraying with the chemical since one can avoid exposure without

undue hardship. But the fact that safety cannot be guaranteed for all persons makes it essential that all reasonable steps be taken to ensure that the public is made fully aware of the intention to spray and the timing thereof in each of the areas to be treated.

5. Evidence presented at the hearing indicated that beekeepers suffered losses during the aerial spraying program. Because bees are a significant part of the ecosystem as well as being important from an economic viewpoint, steps should be taken to ensure that the beekeepers are considered when developing an aerial spraying program and are then fully informed of the chemical spraying operations.

6. There is a need for the earliest possible identification of 'risk possibilities' when western equine encephalitis may threaten. The ongoing program of Arbovirus surveillance, together with the periodic emergency programs, represent a considerable commitment of manpower and funds. The effectiveness of the overall effort is reduced if, during years of a minimal western equine encephalitis threat, the surveillance program is cut for the sake of economy, as has happened in the past. In addition, there are still unanswered questions about the epidemiology of western equine encephalitis and the effect of the efforts to control the disease. To maximize the effect of the western equine encephalitis control/prevention program, it is necessary that such uncertainties be reduced as much as possible. The Commission, therefore, recommends that the surveillance program be provided with stable funding so as to obtain data that is consistent from year to year.

   The Commission furthermore recommends the funding of research into the annual cycle of the virus and into the effectiveness of the current program in modifying the natural course of an epidemic.

# APPENDIX 3

## NEWSPAPER ADVERTISEMENTS OF PUBLIC HEARINGS

# *Public Hearings on Mosquito Control*

**WINNIPEG**
*Norquay Building,*
*Basement Auditorium, 401 York Avenue*

**MAY 12, 13, 14, 1982**
*9:30 a.m.*

THE MANITOBA CLEAN ENVIRONMENT COMMISSION is investigating mosquito control programs in use in Manitoba. The Commission wants to hear from all interested Manitobans and urges them to express their views at the hearing in their area. Verbal submissions may be made at the hearing while written submissions should be forwarded to:

CLEAN ENVIRONMENT COMMISSION
139 TUXEDO AVENUE
WINNIPEG, MANITOBA R3N OH6

*If you are concerned about mosquito control in Manitoba, we would like to hear from you.*

MANITOBA
CLEAN ENVIRONMENT COMMISSION

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# *Public Hearings on Mosquito Control*

**BRANDON**
*City Council Chambers, 410-9th Street*

**MAY 18, 1982**
*10:00 a.m.*

THE MANITOBA CLEAN ENVIRONMENT COMMISSION is investigating mosquito control programs in use in Manitoba. The Commission wants to hear from all interested Manitobans and urges them to express their views at the hearing in their area. Verbal submissions may be made at the hearing while written submissions should be forwarded to:

CLEAN ENVIRONMENT COMMISSION
139 TUXEDO AVENUE
WINNIPEG, MANITOBA R3N OH6

*If you are concerned about mosquito control in Manitoba, we would like to hear from you.*

MANITOBA
CLEAN ENVIRONMENT COMMISSION

# *Public Hearings on Mosquito Control*

**DAUPHIN**
*Allied Arts Centre, 104-1st Avenue*

**MAY 19, 1982**
*10:00 a.m.*

THE MANITOBA CLEAN ENVIRONMENT COMMISSION is investigating mosquito control programs in use in Manitoba. The Commission wants to hear from all interested Manitobans and urges them to express their views at the hearing in their area. Verbal submissions may be made at the hearing while written submissions should be forwarded to:

CLEAN ENVIRONMENT COMMISSION
139 TUXEDO AVENUE
WINNIPEG, MANITOBA R3N OH6

*If you are concerned about mosquito control in Manitoba, we would like to hear from you.*

**MANITOBA**
CLEAN ENVIRONMENT COMMISSION

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# *Public Hearings on Mosquito Control*

**THOMPSON**
*City Council Chambers, 226 Mystery Lake Road*

**MAY 25, 1982**
*10:00 a.m.*

THE MANITOBA CLEAN ENVIRONMENT COMMISSION is investigating mosquito control programs in use in Manitoba. The Commission wants to hear from all interested Manitobans and urges them to express their views at the hearing in their area. Verbal submissions may be made at the hearing while written submissions should be forwarded to:

CLEAN ENVIRONMENT COMMISSION
139 TUXEDO AVENUE
WINNIPEG, MANITOBA R3N OH6

*If you are concerned about mosquito control in Manitoba, we would like to hear from you.*

**MANITOBA**
CLEAN ENVIRONMENT COMMISSION

# APPENDIX 4

## LIST OF SUBMISSIONS

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No. 1 - Report No. 10 of the Canadian Environmental Advisory Council, *A New Approach to Pest Control in Canada*, Ross H. Hall, July 1981.

No. 2 - Representations on behalf of the Environmental Management Division by Dr. W. G. Bowen, Assistant Deputy Minister.

No. 3 - Brief presented by Dr. W. J. Turnock of the Manitoba Environmental Council, *Mosquito Control Programs in Manitoba.*

No. 4 - Brief by Dr. Jean Hollebone, Pesticides Division, Agriculture Canada, *The Role of Agriculture Canada in the Registration of Pesticides.*

No. 5 - Agriculture Canada Trade Memorandum T-1-233.

No. 6 - Representation by Dr. L. Ritter, *The Role of Health and Welfare Canada, Pesticide Registration.*

No. 7 - Representation by Dr. N. Y. Khan, *The Role of Fisheries and Oceans Canada, Pesticide Registration.*

No. 8 - Brief presented by Dr. J. D. Campbell, Consumer's Health Organization of Manitoba, on behalf of Dr. P. Aitchison.

No. 9 - Brief presented by Dr. R. Brust, *Mosquito Dispersal and Distribution.*

No. 10 - Presentation by Dr. J. E. Hollebone, Pesticides Division, Agriculture Canada, *Chemicals Registered for Mosquito Control Programs in Canada.*

No. 11 - Presentation by Prof. M. Samoiloff, *Concerns Related to Chemical Control Programs.*

No. 12 - Presentation by Dr. M. Chance, *Alternatives to Chemical Mosquito Control Programs.*

No. 13 - Presentations by Mr. Flint, Dr. Hulpke, Dr. Lamb, and Mr. Misener, on behalf of Chemagro, *Role of Manufacturers and Suppliers of Chemicals.*

No. 14 - Presentation by Dr. F. S. LaBella, *Risk/Benefit Considerations in the Use of Pesticides for Mosquito Control Programs in Populated Areas.*

No. 15 - Brief presented by Mrs. Doersam.

No. 16 - Presentation by Dr. R. A. Ellis, on behalf of the City of Winnipeg, *Assessments of Baygon: Effectiveness Against Mosquitoes.*

No. 16A - Efficacy Reports on Adulticiding.

No. 16B - Efficacy Reports on Larviciding.

No. 17 - Presentation by Dr. G. Surgeoner, *Mosquito Control Programs in Ontario.*

No. 18 - Presentation by Dr. J. A. Eadie, Manitoba Provincial Epidemiologist, *History and Background of Western Equine Encephalitis* and *Role of Arbo Virus Committee.*

No. 19 - Presentation by Dr. R. A. Brust, *Population Dynamics of Mosquito Vectors in Manitoba.*

No. 20 - Presentation by Mr. Don Dixon, Provincial Apiarist, *The Effects on Honey Bees of the 1981 Manitoba Emergency Mosquito Abatement Program.*

No. 21 - Presentation by Mr. G. Kreutzer, President, Manitoba Beekeepers Association.

No. 22 - Presentation by Mr. Vere Scott.

No. 23 - Letters received by The Clean Environment Commission from concerned citizens.

No. 24 - Presentation by Mr. H. Eckert on behalf of Emergency Measures Organization, *Mosquito Action Guidelines for a Health Emergency (WEE).*

No. 25 - Presentation by Mr. H. Eckert on behalf of Emergency Measures Organization, *Mosquito Abatement Program 1981, Public Information Centre.*

No. 26 - Table of Surface Water Samples.

No. 27 - Presentation by Mr. H. C. R. Gavin on behalf of Environmental Protection Services, Environment Canada.

No. 28 - *Mosquito Spray Program - Manitoba Sugust 1981 Baygon Droplet Monitoring.*

No. 29 - Presentation by Dr. Lockhart, *Summary of Remarks with Attached Research Papers on Experimental Cholinesterase Inhibiting Depression from Baygon Intoxication in Birds.*

No. 30 - Brief by Mr. Kenneth Emberley with attached papers.

No. 31 - Brief presented by Dr. David Millar.

No. 32 - Papers submitted by Mrs. Alice Zeiler.

No. 33 - Representation by the Westman Branch of the Consumers' Association of Canada, presented by Mrs. Colleen Elliot, President.

No. 34 - 1981 Annual Report of the City of Brandon Mosquito Abatement Program. September 1981.

No. 35 - Report submitted by Dr. Joseph E. Cummins, Department of Plant Sciences, University of Western Ontario, *Production of Nitroso Baygon from Baygon in* $NO_2$ *Gas.*

No. 36 - Paper submitted by the Manitoba Naturalist Society.

No. 37 - Report submitted by Dr. Peter Warner, Director, Environmental Health, Manitoba Department of Health, *Health Considerations in the Use of Insecticides in the Prevention of Western Equine Encephalitis.*

# APPENDIX 5

## HEALTH CONSIDERATIONS
## IN THE USE OF
## INSECTICIDES IN THE PREVENTION OF
## WESTERN EQUINE ENCEPHALITIS

# HEALTH CONSIDERATIONS IN THE USE OF INSECTICIDES IN THE PREVENTION OF WESTERN EQUINE ENCEPHALITIS

by

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## ABSTRACT

This paper examines the health considerations of the use of propoxur as an aerial spray in Manitoba for the prevention of Western Equine Encephalitis (WEE) and consists mainly of a review of information from a publication on propoxur published by the National Research Council of Canada.

Comparisons were made of the "no-effect" and Acceptable Daily Intake (ADI) levels and the estimated exposure in aerial application with results obtained in human volunteers, an attempted suicide, field workers and exposed populations.

It was concluded that, while pesticides must be regarded as dangerous toxic substances, there appears to be justification for the aerial spraying of propoxur in Manitoba in face of an epidemic of WEE.

Since, without extensive epidemiological evidence, it is not possible to determine the effect of aerial spraying on the spread of Western Equine Encephalitis (WEE), the evidence that it is or was effective must be indirect. In fact, the evidence rests solely on whether the aerial spraying significantly reduced the number of mosquitoes, particularly Culex tarsalis. If it can be shown that, in fact, Culex tarsalis were significantly reduced it would be reasonable to conclude that a significant proportion of Culex tarsalis infected with WEE virus were also reduced and thereby the number of human (and equine) cases of WEE were reduced.

If the conclusion is reached that Culex tarsalis is not significantly reduced by aerial spraying, then aerial spraying, under these circumstances is not justified.

If the conclusion is reached that Culex tarsalis is significantly reduced by aerial spraying, then the question becomes one of whether the harmful effects of the pesticide exceed those of an epidemic of WEE without the intervention of aerial spraying. WEE is a disease with high mortality and morbidity rates, and the question to be answered is whether aerial spraying of the pesticide has morbidity and mortality rates significantly less than those for the disease (it is to be noted that aerial spraying is not expected to affect the rates for WEE - theoretically, at least, if 50% of the mosquitoes were killed, the total number of cases of WEE would be halved but the same proportion of deaths and disability would be expected - in other words the rates of morbidity and mortality for WEE would remain the same).

The pesticide in question (propoxur or Baygon) was assigned by a joint committee of the World Health Organization and the Food and Agriculture Organization a maximum "Acceptable Daily Intake" (ADI) of 0.02mg ai/kg-bw based on a "no-effect level" of 0.2mg ai/kg-bw - this is mentioned for future comparisons.

Most of the following information is derived from the publication entitled "Effects of Propoxur on Environmental Quantity with particular reference to its use for Controls of Biting Flies" published by the National Research Council of Canada (NRCC, 1982).

In the above publication it states that a crude estimate of a heavy exposure in a single application of 125g ai/ha is 0.1mg ai/kg-bw, which is one-half the no-effect level mentioned above (in Manitoba, the application was less than one-half of the above ie: 55g ai/ha).

Propoxur is a reversible inhibitor of brain, central nervous system, erythrocyte and blood serum cholinesterases. Inhibition of cholinesterase reduces transmission of impulses in certain nerves and that is why it is called a nerve-poison but the effects of the poison are reversible.

In addition to anti-cholinesterase activity, the symptoms and signs of intoxication include pressure in the head, blurred vision, nausea, sweating, increased pulse rate and blood pressure, dizziness, abdominal pain, vomiting, diarrhoea, numbness of the face, pin-point pupils, pulmonary oedema and coma.

A 42-year-old human male volunteer received a single oral dose of propoxur of 1.5mg ai/kg-bw and in 15 minutes began to be affected by headache, blurred vision, nausea, sweating, but he started to feel better in another 30 minutes and ten minutes later was back to normal. The dose was 75 times the Acceptable Daily Intake.

Results of several studies in which humans were exposed to propoxur at 0.36 - 1.5 ai mg/kg-bw in single doses or 0.15 - 0.20 ai mg/kg-bw in 5 doses (total dose 0.75 - 1.00 ai mg/kg-bw) at 30 minute intervals (from 18 to 75 times the ADI) showed that:

i) Symptoms of carbamate poisoning could result from a single oral dose of propoxur from 0.2 to 0.4mg/kg-bw.

ii) The reduction of erythrocyte cholinesterase to about 60% of the normal level is possible at doses lower than those in which signs and symptoms of carbamate poisoning are apparent. Recovery is extremely rapid (within two hours).

iii) plasma cholinesterase depression is insignificant at dosages as high as 1.5mg/kg-bw hence depression of the activity of this enzyme would serve as a poor indicator of propoxur exposure.

A conclusion was that the detection of urinary phenolics (isopropoxyphenol) was a more satisfactory test of exposure to propoxur than tests for anti-cholinesterase. This information would be of importance for physicians.

In another trial exposure of four persons (3 male and 1 female) of propoxur to a domestic 2% formulation at a concentration of 3.0± 1.8mg ai/m$^3$ for a period of 4 hours showed neither cholinesterase depression nor impairment of general health. Analysis of urine did reveal detectable amounts of the propoxur metabolites. The level of 3.0mg ai/m$^3$ is six times greater than the Time Weighted Average (TWA) and one and a half times greater than the Short Term Exposure Limit (STEL) set by the American Conference of Governmental Hygienists.

Spray operators were studied after first, second and fifth weeks (with a 50% water dispersible formulation). The whole blood cholinesterase was depressed by about 10,35 and 40% respectively - these returned to normal within 36 hours - it was not mentioned that any signs or symptoms resulted. There did not seem to be any cumulative effects.

A thirty-nine year old woman tried to commit suicide by drinking propoxur. She arrived in hospital in a coma, with pin-point pupils and frothing at the mouth. Her cholinesterase levels were normal (both blood cell and plasma) but propoxur and 2-isopropoxyphenol were found in the gastric aspirate and later in the urine. The woman recovered and is apparently well to the day of publication.

Eleven episodes have been described where operators (88) and general populations (34,477) have been involved. These occurred in Iran, Nigeria and El Salvador where propoxur was used to spray homes in concentrations of 1.5 to 2.0 $g/m^2$, more than 50 times higher than the application rates used for mosquito control in Canada. Signs and symptoms of propoxur poisoning included giddiness, nausea, headache, blurred vision, weakness, sweating, vomiting, pin-point pupils, dizziness, diarrhoea, abdominal pain, skin irritation, numbness or tingling of mouth, nose or face. Generally they disappeared in 24 hours and often within 3 hours. The proportion of people living in sprayed homes who complained varied from zero to 5% (average 0.5%). Of the 88 spray operators 71 (81%) were affected with symptoms ranging from a mild burning sensation to those described above. No fatalities occurred and apparently there were no residual effects. In most cases overexposure of persons other than spray operators could be attributed to entering houses during or immediately after spraying, sweeping sprayed floors without wetting first and direct contact with sprayed surfaces - it was suggested that with a more cautious attitude these situations could be avoided. Also the studies indicated that overexposure to propoxur of spray operators could be avoided by good personal hygiene, proper training, supervision, respirators and protective clothing.

The above information, that is to say: the "no-effect" and ADI levels, the calculated exposure from spray, the work on human volunteers, the observations on field workers and population, all seem to indicate that the acute short term effects of propoxur were reversible and even with large doses no mortality was reported - such adverse episodes as were described were either intentionally caused or appeared to be the result of badly conducted programs.

When it is borne in mind that the rate of application in Manitoba was less than one-half of that quoted in the NRC publication and 100 times lower than the programs in Iran, Nigeria and El Salvador, it would seem that the exposure of people to the aerial spray program in Manitoba is likely to have resulted in a negligible effect on them.

As far as more chronic effects are concerned: none appear to have been described - in one episode skin rashes were reported in 5% of 200 people but subsequent investigation indicated that this was not a regular phenomenon.

As far as long-term effects are concerned, long-time dietary exposure studies with rats and mice do not indicate that propoxur is carcinogenic or mutagenic in animals.

It has been claimed that it is possible for propoxur to be "nitrosated" (particularly in the stomach) to form a substance of the nitrosamine class. Some nitrosamines are known to be carcinogenic - but there are many nitrosamines some in foods and some can be detected in normal gastric juice.

While it can be said that a substance is carcinogenic, it is not possible to state, even with the best designed animal experiments, that a chemical particularly a complex organic chemical, is not carcinogenic. However, it is claimed that if nitrosopoxur is formed at all, it is formed in small quantities and no evidence exists that it has caused cancer in humans or animals.

To look at this in a slightly different way, WEE is a disease with at least 10% mortality and lifelong disability whereas, in 1980, deaths from malignant neoplasms from all causes in the USA was 0.1752% - it would not be unreasonable to conclude that the risk of death or lifelong disability is at least 100 times greater in WEE than with exposure to a speculative carcinogen.

Thus if it can be asserted that aerial spraying with propoxur diminishes Culex tarsalis in significant numbers it is reasonable to conclude that WEE is diminished proportionately (such assumptions are not uncommon in medicine and in all types of research) then it is difficult to deny that aerial spraying is justified in the face of an epidemic of WEE.

It has been suggested or even directly stated that there is a vast lack of knowledge about pesticides to the extent that it could be considered irresponsible to recommend their use. In addition, others have issued very serious warnings about the toxicity of pesticides. It cannot be denied that there are gaps in knowledge nor that pesticides in general are toxic nor, if one catalogues all the toxic effects and all the adverse episodes relating to pesticides used or misused, that they are very dangerous and frightening chemicals. But, in the specific case of propoxur, which has been in existence for nearly twenty years, not only does there appear to be a considerable amount of information but also there appears to be justification that, if used as directed, in an occasional aerial spraying program, the risk of toxicity is very small.

Finally, it has been suggested that because the mortality of WEE is only two per cent of all those infected (not all those infected actually contract the disease, case-mortality is the proportion of those who contract the disease and die and would be much higher than two per cent and is stated to be 10%) and that, by allowing those who become infected to become naturally immune to the disease, the population would build up its resistance to WEE without the necessity of an aerial spraying program. However, this suggestion was accompanied by a requirement that the annual mosquito abatement program would be continued. Quite apart from the possibility that only 20% of the population would be immunized, the annual use of pesticides raises questions in addition to those that are dealt with in this paper.

In conclusion, while chemical pesticides must be regarded as dangerous toxic substances, there appears to be justification for the aerial spraying of propoxur in Manitoba in face of an epidemic of Western Equine Encephalitis.

## REFERENCE

National Research Council of Canada 1982. Effects of Propoxur on Environmental Quality with Particular Reference to its Use for Control of Biting Flies. NRCC18572. 238pp.